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GLIMPSES OF THE GREAT AMERICAN DESERT

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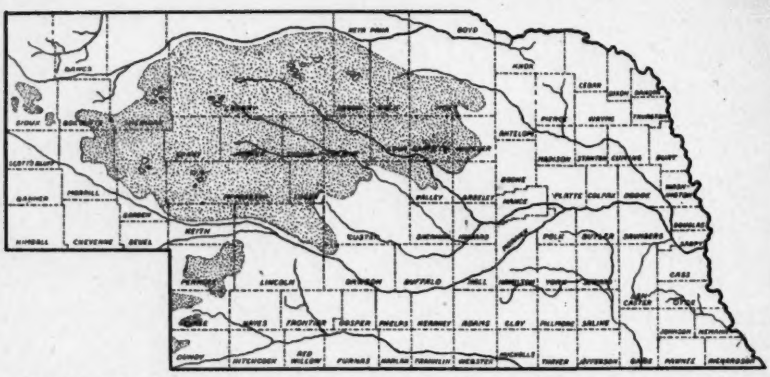
THOUSANDS of years ago when the forces of nature were at work shifting and gradually shaping the features of the Great Plains, large areas of Tertiary sandstones were exposed in Dakota, Wyoming, Nebraska, Kansas and other parts of the western plains. As topographic features were slowly evolved, these sandstones, being young and soft, readily yielded to the eroding action of the elements and were reduced to light, fine-grained sand. In addition to this sand formed *in situ* probably considerable amounts of other sands were washed or blown into the region from farther west. Great quantities of the sand thus formed were caught up by the wind and heaped into mounds that finally grew to be large sand dunes extending in long ranges and ridges for many miles over the sandstone beds. Thus were the Sand Hills of the Great American Desert formed in the days preceding the advent of plants or men into the regions now characterized by the billowy hills covered with the bunch-grasses and their associates.

The Sand Hill landscape in these early days was probably a restless maze of wandering sand dunes. In later years certain plants crept in from the surrounding plains, only to be uprooted and blown away. After many such invasions some individuals finally succeeded in maintaining a foothold in the more protected portions of the hills. Notwithstanding the terrible conditions imposed by an arid climate and a continually shifting soil, vegetation continued to spread to other areas from these primary centers of establishment.

Some time after the Sand Hill flora had gained a lasting hold upon the dunes and the greenish hue of vegetation had spread over the great expanse of hills, enormous herds of bison came charging into the region



THE SAND HILL AREAS ARE INDICATED BY THE SHADED PORTIONS ON THE MAP.

in quest of forage. The vegetation was closely grazed and tramped into the unstable soil. And then the red man came, who killed the bison for food, clothing and for many other useful purposes. He sought to improve the range for the wild beast and for his own stock by burning the grass at certain seasons of the year. In this way a third and still greater menace was forced upon the plants that were struggling so hard to cover the Sand Hills with a permanent mantle of vegetation.

The Sand Hill region of Nebraska is one of the largest and best known portions of the sand hills of the Great Plains. In our state the main body of Sand Hills is oblong in shape with irregular margins. This region lies north and west of the central portion of the state. On the northern edge of the region there are numerous deep canyons with steep, more or less wooded sides. A few more or less isolated areas of Sand Hills occur outside this great main region both north and south of the Platte. A glance at the accompanying map will show the location and comparative size of the main region and the outlying areas of sand hills.

The Sand Hills of Nebraska cover an area of more than 18,000 square miles, almost one fourth of the total area of the state. This is about equal to the combined areas of New Hampshire and Vermont. The hills are all round-topped or conical and smooth, clearly showing that they had been shaped by the wind long before their invasion by plants. There are many depressions between the hills, many of which assume the proportions of valleys more than a mile in width and sometimes many miles in length. From these well-developed valleys the low places decrease in both width and length until they are mere narrow, saucer-shaped basins or "pockets" a few hundred yards across. The well-pronounced valleys are, as a rule, about parallel and trend in a general southeast and northwest direction. Such valleys are frequently completely inclosed by ranges of hills and in this way effectively separated from adjacent valleys, though such may not be more than a half

mile distant. Sometimes instead of the valleys being separated by a range of round-topped hills this is accomplished by a continuous rounded ridge. The sides of these hills are often very steep, making difficult the direct passage over from one valley to another.

In the regions of widest valleys the ranges of hills often show a succession of higher hills as one passes back from the valley to the highest points on the divide, which may be from 300 to 400 feet above the level of the valley. In the regions characterized by short valleys and basins the general landscape is strikingly different because in such places the hills rise on all sides without any regularity. Low hills, intermediate hills and high hills are all closely associated, with no long separating valleys. The result is a very abruptly rolling surface with rounded or oblong depressions of varying depth, with the rounded or conical dunes above. There are places where this sort of topography stretches in all directions as far as one can see.

As the name implies, the hills are composed of sand. This sand is of a light straw color (not white) composed mostly of fine grained quartz. The purest sand is found in the newest soil areas such as in "blow-outs" or other places where the overlying vegetation has been completely removed by the wind. In many places, notably on the river flats and in the numerous thickets scattered throughout the hills, there is a copious admixture of organic remains and so the surface soil in such places is a rich black sandy loam and is very fertile. But the characteristic soil of the region as a whole is the pure dune sand composed of very fine particles. As to the chemical nature of the sand, the following table shows it to be very high in insoluble mineral matter and very low in soluble organic or inorganic plant-food materials.

COMPOSITION OF SAND HILL SOIL[1]

	From Forest Nursery	From Tops of Hills
Insoluble matter	91.80	97.40
Potash	0.14	0.05
Soda	0.42	0.42
Lime	0.38	0.12
Iron oxide	0.01	0.01
Alumina	2.76	0.84
Phosphorus pentoxide	0.06	0.03
Sulphur trioxide	0.19	0.21
Water and organic matter	4.24	0.92
Total	100.00	100.00

The following table shows the size of the soil particles in per cent., and the average of three determinations from different stations in the Sand Hills:

[1] From a series of analyses by Dr. Samuel Avery, 1905.

SIZE OF SOIL PARTICLES[2]

Size in mm.	2.0–1.0	1.0–0.5	0.50–0.25	0.25–0.10	0.10–0.05	0.05–0.01	0.01–0.005	0.005–0.0001
Station 1.....	0.00	0.12	3.28	70.05	22.29	1.14	0.23	2.12
Station 2.....	0.00	0.41	8.59	46.62	39.56	0.86	0.28	3.35
Station 3.....	0.08	1.15	8.20	40.07	39.17	2.98	0.63	5.05
Average of 3 stations.....	0.02	0.56	6.69	52.24	33.67	1.66	0.38	3.50

Such a loose sandy soil soaks up moisture very readily, so that after a heavy fall of rain scarcely any water is drained from the surface into the valleys, but all of it goes into the porous soil. Now and then rainstorms of such torrential fierceness occur in the hills that a great quantity of the sand is brought down from high on the hills and carried into the valleys. Such storms are, however, exceptional, since the usual heavier rains of about 1.0–1.5 in. are completely taken up by the sand, with no surface drainage at all.

In connection with the distribution of soil water in the Sand Hills it is interesting to note that, although the surface of the sand is commonly as dry as powder, the sand but a few inches beneath the surface is quite moist. The average of many soil samples taken during July, 1911 (a wet month for that year), in widely isolated stations at a depth of twelve inches, showed the water content to be 3.27 per cent. The Sand Hills rest upon a series of relatively impermeable clays and stratified rocks. These layers of more solid materials crop out from the surface along streams and on the lower slopes of some hills quite remote from the deeper valleys. The soil is always moister upon a slope with these outcrops than in situations where such are absent.

The annual precipitation over the main body of Sand Hills varies from twenty-three inches in the east to about fifteen inches on the western border. April, May and June are usually the wettest months of the year, while the dry season frequently continues from August to March or the first of April.[3] In the central Sand Hills during the month of July, 1911, five and one half inches of rain fell. At the government forest nursery near Halsey (Thomas County) during this month there was scarcely a day that rain did not fall. The showers were usually light, but a few were soaking rains. Hail sometimes accompanies these thunderstorms in such quantity that a great amount of damage is done to gardens, crops and other property.

Most of the precipitation disappears into the soil at once. It is a rare sight, if indeed it ever happens, that any of the streams or lakes of the region show an increase in volume resulting from the run-off from

[2] From Professor E. H. Barbour, Nebr. Geol. Survey, Vol. 1, 1903.

[3] Data from official records of U. S. Forest Service at Halsey, Nebr., for last seven years.

even the heaviest downpour. Because of the general porous nature of the soil the region is characterized by sub-surface drainage. The fluctuations in the ground water from time to time produce differences in the level of the lakes and ponds. During especially wet seasons the level of the lakes may be perceptibly elevated, due in all probability to seepage from the surrounding hills.

The most important stream of the Sand Hills is the Loup River, the three forks of which rise in low swampy flats toward the central portion of the region. Through the Sand Hills portion of its course the Middle Loup has a fall of about eight feet per mile and so develops considerable current which causes its bed and its channel to shift continually. The sand banks are cut and the channel veers from side to side along its course. This tendency culminates in the formation of many "oxbows"

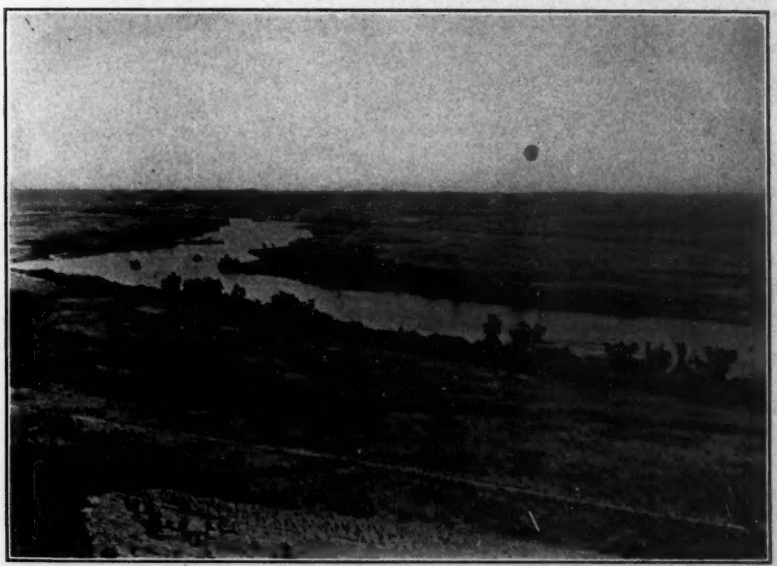


FIG. 1. THE MIDDLE LOUP RIVER WITH FRINGES OF WOODY VEGETATION. Sand Hills in the distance.

or loops. Some of these loops are most perfect and beautiful as viewed from far up in the hills. The streams of the region are all shallow, the Loup varying from one to six feet in depth with a channel about fifty yards wide. In many places such streams are extremely beautiful with their winding channels of clear swift water and fringes of vegetation.

The Dismal River is an important tributary to the Loup. Heading in the swamp and lake region of Hooker, Grant and McPherson counties, it continues eastward for about seventy-five or eighty miles, and pours into the Loup at Dunning. This river is an especially welcome sight as

one suddenly comes upon it hidden in a deep valley (almost a gorge in many places) after a long, slow, hot ride of thirty miles or more over the hills. The Dismal has cut in a number of places a very deep canyon through the hills. Often the sides of this canyon are almost perpendicular, while elsewhere the banks are not so high or steep. Now and then the stream leaps over a ledge of sandstone producing a waterfall a few feet in height which adds to the beauty of the landscape. There are in truth many spots along the Dismal that would make worthy subjects for the landscape painter.

Few would classify Nebraska among the states with lakes, but as a matter of fact there are hundreds of lakes in the state. Many of these lakes are in the Sand Hills, where they usually occur in groups of few to many in various parts of the region. The largest group occurs in Cherry County, with fifty or more lakes. Some of these, such as Hackberry, Dad's, Clear, Willow, Dewey, Red Deer, etc., furnish excellent sport to the fisherman and the hunter. Aquatic vegetation furnishes abundant food for both fish and fowl. The lakes vary from small ponds a hundred yards across to bodies of water a mile or more wide and four to five miles long. From the top of a certain hill in Cherry County more than twenty such lakes may be seen.[4]

There are many people who still think that the Sand Hill region is a plantless waste of wandering dunes. This is far from fact, but nevertheless the vegetation of the region is sparse and there are also many instances of actively moving sands, although by far the greatest portion of the area is effectively protected from wind erosion by the presence of vegetation. Nowhere except in the moister habitats, as in the valleys, do the plants grow densely or close together. On the hills proper the light-colored sand always shows between the individual plants. In places one may cross over areas two hundred yards or more in width and count all of the plants in his path on his fingers.

Notwithstanding the sparseness of the vegetation there are very many species represented in the Sand Hill flora, but in spite of this great number of species that are found over the hills and ridges and in the valleys, the most striking characteristic of Sand Hill vegetation is its great monotony due to the domination of bunch-grasses, which are the controlling elements of the floral covering of the whole region. The bunch-grasses are so named because from each root there arise many straight, wiry stems in close proximity, so that a clump or bundle of fifty to a hundred or more stems are densely crowded together. These bunches occur more or less scattered in a way such that the characteristic tufted nature of the vegetation results, and the numerous smaller species that occur in the intervals are quite effectively concealed.

[4] Pound and Clements: "Phytogeography of Nebraska," 1898.

A continuous association composed of bunch-grasses is the typical vegetation of the whole Sand Hill region. This covers the hills and ridges over thousands of square miles, being absent only from the "blow-outs" and the moister valleys. Once established in the sandy soil the bunch-grasses cope very successfully with the fury of the wind and the shifting sand. However, if fire or over-grazing seriously reduces the bunches in size and vitality, subsequent winds may uproot and carry them away. But on the whole the bunch-grasses are very effective sand binders, and it would be a great calamity indeed if they

FIG. 2. A FREQUENT SIGHT: OVER-GRAZING OFTEN RESULTS IN BARE HILLS AND BLOWING SAND.

were to be removed and nothing substituted. It is due to them more than to any other single type of plants that the vegetation of the hills is enabled to persist. Within the shelter of the bunch-grass association scores of valuable species thrive that in its absence would never have found access to the region.

The bunch-grass *par excellence* is the little blue stem (*Andropogon scoparius*), but associated with it are others, such as sand grass (*Calamovilfa longifolia*), and needle grass (*Stipa comata*). *Andropogon scoparius* is the dominant species throughout the region, the other species being present only occasionally. It is the little blue stem that gives the first greenish hue to the sand hill landscape in the spring, and it is the same species that clothes the hills with the rich reddish-purple in the autumn and through the winter. Hall's blue stem (*Andropogon hallii*), common on the upper slopes of the hills and the tops of ridges, is usually of secondary importance. Its few tall whitish or bluish stems

in poorly defined bunches are, however, conspicuous wherever they are found.

Within the bunch-grass association there are a number of secondary types that are quite well defined. But as one views the vegetation of the Sand Hills in a general way these are lost in the great monotony of the bunch-grass association. However, the vegetation and general life conditions of the uplands, the home of the bunch-grasses, are very noticeably different from those characters on the river flats or in the wet valleys. The exposure to both the drying and the mechanical effects of the wind is most keenly felt on the uplands, composed of the hill tops and upper slopes. Sometimes the wind sweeps over the crests of the hills with such terrific force that one can not stand in its path and endure the sting of the sand blast. During a bright day with a high temperature and such a wind, life on the hills is well nigh impossible. During the hottest days of summer the surface sand in such situations is frequently heated to a temperature of 140° F. Such conditions with a low water content of the soil and a high saturation deficit are the factors that plants must meet. One can not but admire the vegetation that possesses the power of successfully resisting such a combination of conditions. That Sand Hill vegetation has been very successful in meeting these conditions is fully attested by a glance at the region as we find it to-day and a comparison with the dismal waste of bare sand dunes that once wandered over this same area.

Aside from the bunch-grasses, the most characteristic plant of the uplands is the dagger weed (*Yucca glauca*) which often occurs in great abundance on the upper slopes. In certain portions of the region over restricted areas this species really becomes dominant and the bunch-grasses then play only a subordinate part in the floral covering. The dagger weed reaches its best development on the south and west exposures, although it is by no means confined to these slopes. The sand is often blown away from the roots for many inches beneath the rosette of bristling leaves, and yet the plant continues to thrive. Frequently it puts out new shoots from the exposed roots and develops new rosettes of leaves beneath the old.

The so-called "cat steps" formed on steep slopes in the Sand Hills owe their origin to the grazing habits of cattle and very frequently to the presence of dagger weeds. On such slopes the cattle, avoiding the sharp-pointed leaves of the *Yucca,* follow angling paths which eventually become netted and worn into the sand in such a way as to cover the hillside with a network of trails. Clumps of dagger weed often fill in the more or less diamond shaped meshes of this network. From a distance, such a slope bears a close resemblance to the "cat steps" so commonly seen on steep slopes in the loess region. The origin is, however, very different. One may find in the Sand Hills a great many stages in

the development of these netted trails. They are not necessarily always associated with the dagger weed, since they also occur on slopes with bunch-grasses only.

Like the little blue stem, the dagger weed has little value in the region aside from its interesting and important rôle in the life history of the ridges and slopes. Some economic value is attached to it in that it is eaten by cattle to a slight degree. Especially when the plant is in bloom, if the range is rather short, stock frequently strip every juicy flower from the large spike or panicle, sometimes even eating the axis well down among the needle-tipped leaves. I have seen them attack the young capsules when the range is especially short, so that in a closely grazed pasture one seldom finds a single fruit of the species.

FIG. 3. THE DAGGER WEED IN FRUIT.

Besides the bunch-grasses and the dagger weed there are many other species that occur in greater or lesser frequency in the bunch-grass association. The hairlike eragrostis (*Eragrostis trichodes*) is an important secondary grass of the uplands that frequently shows the bunch-grass habit. So also Indian millet (*Oryzopsis cuspidata*), and the black grama grass (*Bouteloua hirsuta*) are quite commonly seen in the intervals between the bunch-grasses. In fact there are more than one hundred species of grasses alone in the Sand Hills, many of which are confined to the uplands. Besides the species already mentioned the following are other common associates of the bunch-grasses: Annual eriogonum (*Eriogonum annuum*) which, with its slender, gray flowering stems and conspicuous flat-topped clusters of flowers, occurs as widely

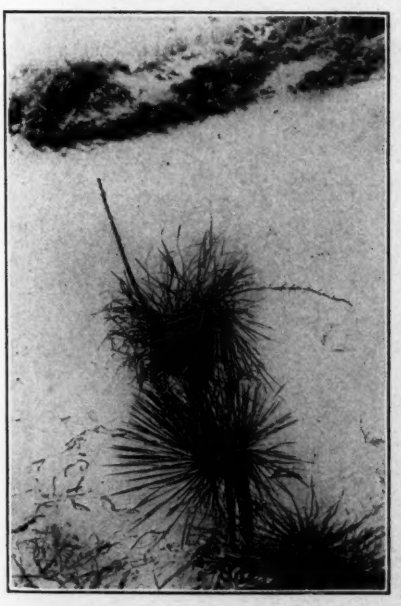


FIG. 4. THE DAGGER WEED MAY ADJUST ITSELF TO A CHANGING SOIL LEVEL.

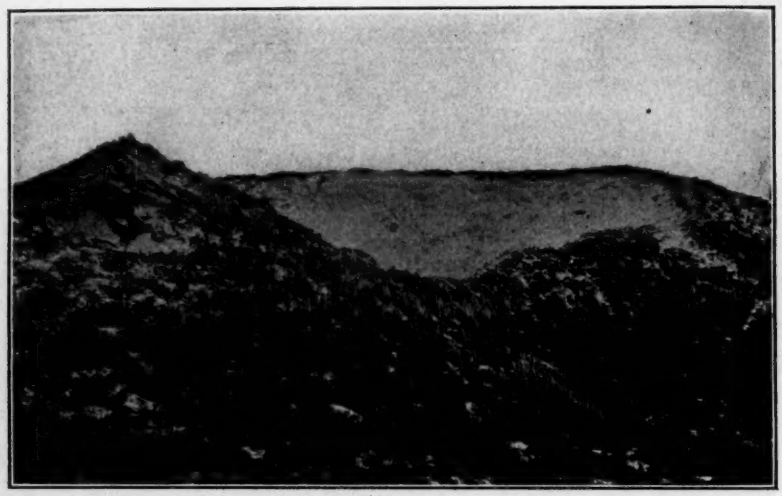


FIG. 5. A BLOW-OUT FROM THE WEST. Bunch-grasses on the outside, *Redfieldia* on the inside.

scattered individuals here and there, or may occasionally form rather dense communities; spiderwort (*Tradescantia virginica*), tufted hymenopappus (*Hymenopappus filifolius*), purple blazing star (*Lacinaria squarrosa*), lance-leaved psoralea (*Psoralea lanceolata*), western thistle (*Carduus plattensis*), rough sunflower (*Helianthus scaberrimus*), prickly poppy (*Argemone intermedia*), long-leaved milk vetch (*Phaca longifolia*), green milkweed (*Acerates viridiflora*), switch grass (*Panicum virgatum*), prairie pink (*Lygodesmia juncea*), Geyer's spunge (*Euphorbia geyeri*), yellow evening primrose (*Œnothera rombipetala*), sweet pea (*Lathyrus ornatus*), and hairy golden aster (*Chrysopsis villosa*). All of these plants occur as scattered individuals except the milk vetch and prairie pink, which are often gregarious. They all show striking anatomical characters that doubtless aid in their survival in such dry soils, exposed to such trying climatic conditions.

In addition to the grasses and the common herbaceous associates the vegetation of the upland is rich in species of low shrubs. In many restricted localities these under-shrubs compose the bulk of the vegetation and really rival the bunch-grasses in dominance. Among these low, much branched, woody plants, New Jersey tea (*Ceanothus ovatus*), Bessey's sand cherry (*Prunus Besseyi*), poison ivy (*Rhus radicans*), and the prairie clovers (*Kuhnistera purpurea, K. villosa,* and *K. alba*) are the commonest and most widely distributed. All of these plants are dwarfed, much branched shrubs often growing in communities. New Jersey tea is found most frequently near the tops of the hills on north facing slopes, where the dense, light

green patches from ten to seventy feet across contrast very greatly with the surrounding bunch-grass vegetation. Bessey's sand cherry is one of the most ubiquitous plants of the whole region. It is found in almost every site of the uplands and with its low, short twigs with tufts of glossy green leaves is seen springing from the sand on practically every side of every hill. Very frequently it forms extensive communities. The prairie clovers seldom form well-defined communities, but they occur as more or less scattered individuals, especially on the lower slopes of the hills adjacent to the larger valleys.

The most striking habitats of the uplands are the "blow-outs." Blow-outs are conical or rounded depressions of varying depth and diameter formed by the blowing of the sand and vegetation from certain spots on the upper slopes and crests of the hills. The rim of the more or less conical depression is sometimes almost circular but it is usually irregular with a general circular outline. Since the prevailing winds of the region are from the west, and since "blow-outs" are the direct products of wind action, these peculiar structures are mostly confined to the west sides of the hills. The greatest number occur on the northwest-facing slope, but they range in position from northwest to southwest, depending somewhat upon the shape of the hill concerned and its relation to the adjacent hills. Blow-outs do not occur on all hills, nor does a single hill show more than a single blow-out, as a rule.

On an exposed upper slope when the vegetation becomes broken or seriously depleted from any cause, the wind as it sweeps up the slope catches the sand and carries it over the crest of the hill a few yards farther away and deposits it upon the lee face of the hill. In this way

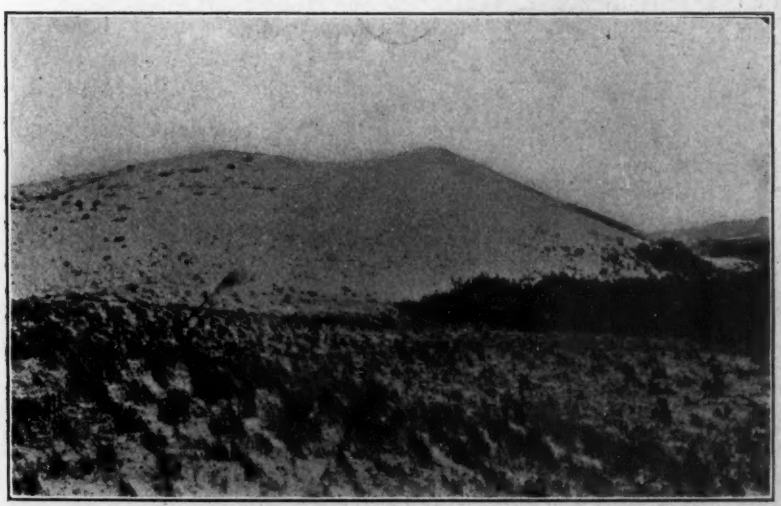


FIG. 6. A BLOW-OUT FROM THE EAST. The sand has been blown out of the crater on the other side. Bunch-grass in the foreground.

FIG. 7. DETAIL IN BLOW-OUT SHOWN IN FIG. 5. The only plant here is *Redfieldia flexuosa*.

as more and more sand is carried away and the up-rooted plants are swept on with the gale, the embryonic blow-out comes rapidly into existence. At this early stage it appears as an area of bare sand a few feet or yards across, over which the wind sweeps and continues to eat its way deeper and deeper into the sand. During this early stage the deep-seated roots of woody plants frequently appear strewn over the surface of the shallow depressions until the wind has finally eaten its way far below the point of penetration of the deepest rooted plants. At last the whole rounded or conical hill top is blown away and a deep crater is developed in its stead.

The two chief factors that enable the wind to begin this work of destruction are fire and over-grazing. Both factors frequently result in reducing the vegetation to a point below effective wind resistance and as soon as this is done, if the exposure be right, wind erosion begins. Nothing is quite so terrible as a prairie fire in paving the way for shifting sands and the development of blow-outs, since in such cases absolutely everything above the surface is destroyed. And so if cattle are allowed to run for too long a time over a given range the grasses are seriously reduced and the soil is tramped bare of plants for considerable distances, making it very readily possible for the wind to strike at the open sands. The effects of over-grazing are contrasted to a striking degree in the Sand Hills, where a fence separates the over-grazed pasture from the ungrazed range. Such sights have resulted in the enactment of grazing laws which naturally do not in all cases please the cattlemen, but they do usually protect the range and make it more stable.

When the young blow-out is no more than a foot in depth the sand begins to slide into the depression from the sides. This sand is blown

away and more continues to slide in, and in this manner the blow-out increases in area as well as in depth. These two processes continue for a number of years until, in many cases, the well-developed crater-form depression is blown out of the hill. Naturally with the increasing depth of the blow-out the direct force of the wind becomes considerably checked by the prominent rim of the crater. But peculiarly enough, as the wind strikes the farther slope of the blow-out a reverse current is developed which strikes beneath the rim and dips into the bottom of the crater. In this way a spiral wind movement is frequently developed and the wind reaches to the very bottom of the blow-out, which may now be fifty or more feet below the rim. This grinding action of the wind continues to loosen more sand at the sides, causing it to slip more and more into the bottom, where the wind catches it and hurls it up over the sloping interior surface of the blow-out and out over the rim. This action is quite appropriately called the "sand mill." The action of these spiral currents are conspicuous during rather low winds as well as on very windy days. Such activity is a very important factor in hollowing the blow-outs to the greater depths.

After many years of this sort of growth, blow-outs at the end of their maximum activity become enormous depressions with a rim sometimes 300 to 900 feet in circumference with sides of bare sand sloping inward at an angle of about 30 degrees to the bottom, which may be from 20 to 75 feet or more beneath the rim. In the western portion of the region where blow-outs are formed in rather low hills among the lakes the sand is removed from the interior until the water table is reached.

During the years of greatest blow-out activity plants fail absolutely to gain a foothold and establish themselves in the blow-out be-

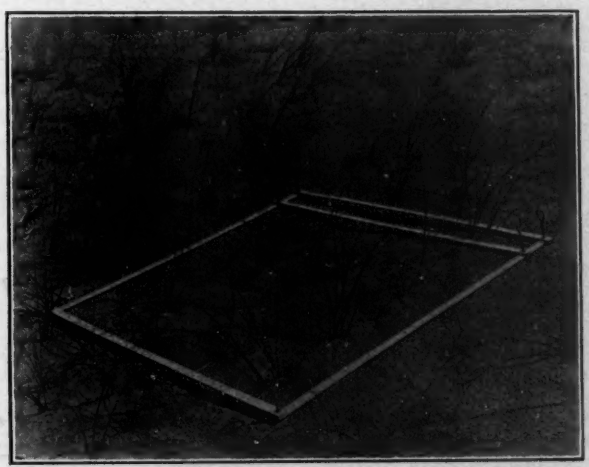


FIG. 8. A SQUARE METER QUADRAT ON THE SLOPE SHOWN IN FIG. 7.

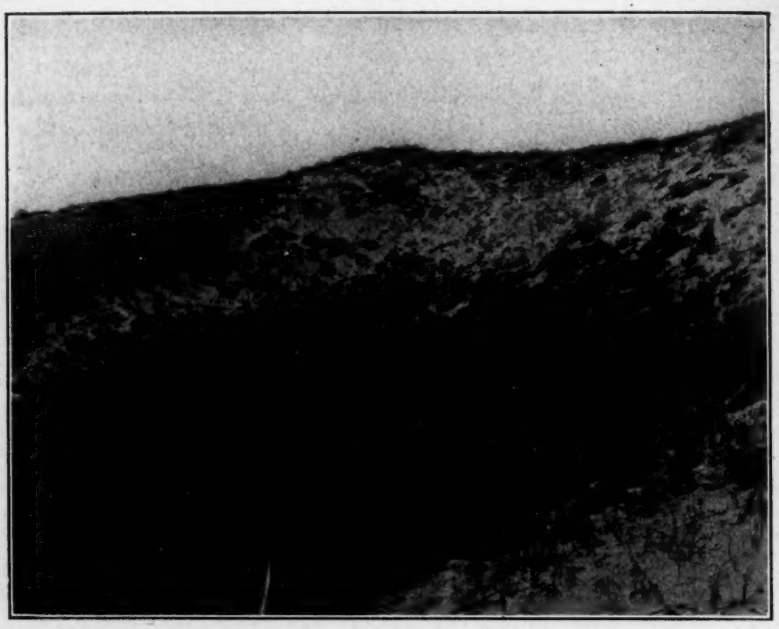


FIG. 9. A LATE STAGE IN THE RECLAMATION OF A BLOW-OUT; the bunch-grasses have now appeared and are creeping up the slope.

cause of the great exposure to wind and shifting sand. The combined action of a high wind, high soil temperature, excessive evaporation, and an unstable soil in the active blow-out, is a condition that plants can not survive. Sooner or later, however, because the blow-out has reached such a depth that the "sand mill" becomes ineffective and the sliding sand fails to reach the bottom, certain plants appear in the bare sand of the blow-out. From this time the terrible physical conditions begin to wane and the vegetation gradually creeps up from the bottom of the blow-out and slowly becomes the master of the situation. The decadence of the blow-out is traced in the development of the vegetation from these first successful invasions until the whole crater-like depression is claimed by the bunch-grasses and their common neighbors.

The first plants to become established in such places are certain grasses commonly called "blow-out grasses." The most important of these is Redfield's grass (*Redfieldia flexuosa*) which is almost always the very first pioneer in the reclamation of the blow-out. *Redfieldia* may be the only plant in such situations for many years. All during this time it is extending its area by undermining and binding the soil with its network of slender rhizomes. From these rhizomes there arise tufts of long, flexuous, narrow leaves gracefully nodding in the gentle breeze or lashing about like so many slender wires in the higher winds. Sometimes in a single windstorm the sand level about these tufts may

be reduced two inches or more, but seldom are the plants uprooted. It is to the rhizome habit of propagation that *Redfieldia* owes its success in thus so completely capturing the blow-out. The later invaders are also provided with this device, which certainly is the key to the whole situation.

After *Redfieldia* has once taken charge of the habitat other species soon begin to wander over the rim of the blow-out and to invade the area occupied by the first blow-out pioneer. Among the first of these early invaders we must number the spiny blow-out grass (*Muhlenbergia pungens*), sand grass (*Calamovilfa longifolia*), and the hair-like eragrostis (*Eragrostis trichodes*). From the appearance of these grasses the decline of the blow-out is rather rapid. As these various species wander up the steep sides, and the force of the wind striking upon the upper slopes is reduced and the sand held from blowing, other species wander in from the bunch-grass association. If these new plants are properly provided with a rhizome device like that of their predecessors they soon begin to weave themselves into the now conspicuous blow-out association. The plants that most commonly gain entrance soon after the grasses have become well established are prairie pink (*Lygodesmia juncea*), small-flowered psoralea (*Psoralea micrantha*), long-leaved milk vetch (*Phaca longifolia*), and the hairy golden aster (*Chrysopsis villosa*). Indeed, some of these species may get a start in the declining blow-out almost as soon as *Redfieldia*.

In this manner the effect of blow-out conditions are finally so far removed that the bunch-grasses enter and take possession of the area so well prepared by the pioneers in the succession. It is almost pathetic to find that *Redfieldia*, the first plant to appear in the blow-out

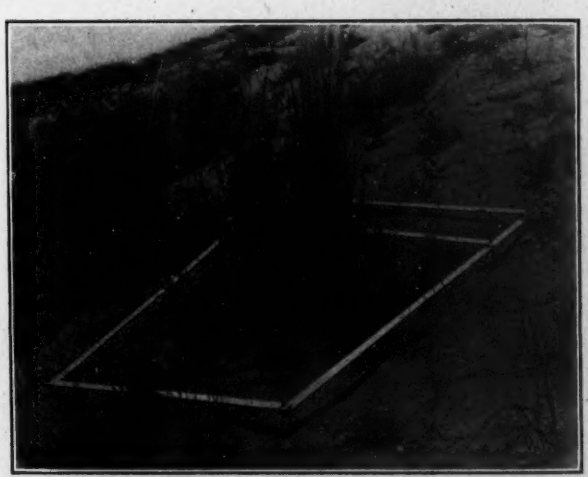


FIG. 10. A SQUARE METER QUADRAT IN THE BLOW-OUT SHOWN IN FIG. 9. The bunch-grass is now conspicuous with a few tufts of *Redfieldia* at the right.

and the plant of greatest importance in its reclamation, after struggling against severe physical conditions for so many years is also the first to disappear. It fails in the competition with the later arrivals and is then forced to find other blow-outs in which it may continue its great work. With the development of the bunch-grasses and the resulting competition all of the blow-out grasses disappear, and then with the incoming of the characteristic members of the bunch-grass association, the change from blow-out to hillside is complete. The only indications of the former history of the place are seen in the grassed-over crater which frequently persists as a characteristic form, and perhaps a few straggling clumps of the blow-out grasses lingering in the near vicinity.

On the lower slopes of the hills and in the valleys many new species are encountered as the bunch-grasses of the uplands are left behind. Rather low down on the north-facing slopes one frequently finds conspicuous associations of willows (*Salix humilis*) and dogwoods (*Cornus stolonifera*). The prairie shoestring (*Amorpha canescens*) also gives tone to the lower slopes in many places by its typical low-branching, ashen-colored plants closely aggregated. Even the taller shoestring (*Amorpha fruticosa*) occasionally wanders from its usual habitat in the moist valley and is found on north slopes among the willows and dogwoods. The presence of such plants always indicates a higher percentage of soil moisture quite near the surface than is found typically in the bunch-grass association. The explanation of this phenomenon is not hard to find, because such associations and such soil conditions almost always mark an outcrop of clay or other impermeable rock strata which lead the ground water from under the hills in a horizontal direction until it is brought near the surface. If the clay or rock does not actually appear on the surface it is usually found a few feet beneath, so that the effect is practically as has been given. The water is frequently so abundant in such situations that it seeps out and collects in cow tracks and other holes in the more tenacious soil. This results in the development of a soggy soil where one finds such moisture-loving plants as marsh mint (*Stachys palustris*), Venus's looking-glass (*Specularia perfoliata*), Solomon's seal (*Vagnera stellata*), heal all (*Prunella vulgaris*), long-bracted orchid (*Cœloglossum bracteatum*), rush (*Juncus balticus*), liverwort (*Marchantia polymorpha*), mosses (*Bryum* sp.), etc. The cow tracks are frequently filled with filamentous algæ and free-swimming animals such as *Euglena*.

The willow thickets, although quite striking structures on the lower slopes, are still well within the bunch-grass association. But as one gets down into the valleys proper the bunch-grasses, and also many of their associates, are left behind. There are two quite distinct types of valleys in the Sand Hills. The dry valleys are relatively short and narrow and with a good covering of grasses which often form a close

sod, but with no standing water. The well-developed sod is a condition that causes the vegetation of the valleys to be quite distinct in appearance from that of the uplands, with the tufted appearance of the bunch-grass association. Such dry valleys are very common throughout the southern portion of the Sand Hills. They yield an abundant crop of

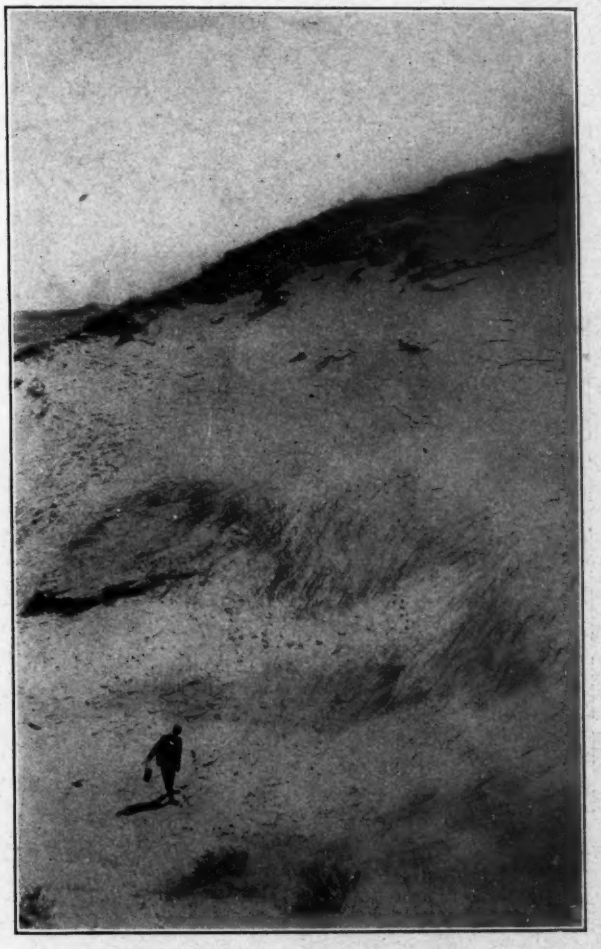


FIG. 11. A DEEP BLOW-OUT; *Redfieldia* on the slopes.

fine hay during moist seasons and always afford very fine forage because of the presence of buffalo grass (*Bulbilis dactyloides*), and grama grass (*Bouteloua oligostachya*) in considerable quantity. The soil of these valleys is not so sandy as the uplands. This with the water table nearer the surface makes possible the culture of certain agricultural crops, if the proper care is taken to prevent the soil from blowing. When the sod is broken in a dry valley where a considerable area of nearly flat soil

is exposed to the wind, the blowing soil frequently prevents the growth of field crops or any other plants.

The flora of the dry valleys is very similar to that of the prairie regions of the state, being especially rich in grasses. The principal widely distributed plants of the dry valley are: switch grass (*Panicum virgatum*), wheat grass (*Agropyrum pseudo-repens*), blue joint grass (*Calamagrostis canadensis*), wild rye grass (*Elymus canadensis*), red top (*Agrostis alba*), tickle grass (*Agrostis hiemalis*), rattlesnake grass (*Panicularia americana*), and a number of sedges (*Carex trichocarpa, C. filiformis,* etc.). All of these species are valuable forage plants and they are all included in most of the hay that is put up from the valleys. Besides these economic plants there are many other herbaceous members of the prairie flora that have wandered into the Sand Hills and have found congenial homes in these dry valleys.

FIG. 12. THE RIM OF A BLOW-OUT WITH THE FRINGE OF ROOTS AND THE SLIPPING SANDS.

The river flats properly belong to the dry valley type, since here we find a soil free from surface water and with all of the above species of plants often growing in profusion. These low flat areas extend from the banks of the river back sometimes several hundred yards to the bases of the hills. These flats or "benches" are well developed along the Middle Loup River. The river winds across the flats in a very irregular course, sometimes cutting close to the hills on one side and then shooting across to the hills on the opposite side of the flat. On these flats and along the bank close to the stream occur the most of the trees of the region. Thickets of plum (*Prunus americana*), and cherry

(*Prunus melanocarpa*), several acres in extent are common in such places. Green ash (*Fraxinus lanceolata*), cottonwood (*Populus sargentii*) and willow (*Salix nigra, S. longifolia*) also thrive on this soil. In the plum thickets near the river the vegetation often becomes so dense that it is almost impossible to penetrate to the river's edge. The soil in these places is very rich and moist, so that many species of the shade plants of moist rich woodlands find in such thickets very favorable conditions. On the open areas of the river flats buffalo grass and grama grass constitute the best forage known in the Sand Hills. These low, sod-forming grasses are especially valuable as winter forage.

Wet valleys are very common in the northern portion of the Sand Hill region, where the valleys are usually broad and long. The water table is near the surface in these valleys, so that the soil in many places is very wet and swampy. There are in this portion of the hills many gradations from the moderately dry hay valley through wet meadow valleys to valleys with large ponds or lakes. Hundreds of lakes occur in such situations throughout the northern half of the Sand Hill region. There have been two general kinds of wet meadows distinguished.[5] The rush-meadow type is characterized by the presence of a number of rushes (*Juncus tenuis* and *J. nodosus*), and bulrush (*Scirpus atrovirens* and *S. americanus*). With these occur a few moisture-loving grasses, such as lowland rattlesnake grass (*Panicularia nervata*) and whorl grass (*Catabrosa aquatica*). In the wet valleys along the Loup River and in wet places on the river flats a second type of wet meadow is seen in the fern meadow. Shield fern (*Dryopteris thelypteris*) and the sensitive fern (*Onoclea sensibilis*) often occur in great quantities in such places with a mixture of willow herb (*Epilobium lineare*), St. John's wort (*Hypericum virginicum*), goose grass (*Galium trifidum*) and marsh bellflower (*Campanula aparinoides*). Frequently the ferns are so dense as to cause considerable difficulty in walking through this type of wet meadow.

There are two kinds of lakes in the Sand Hills, depending upon the amount of dissolved substances in the water, alkali lakes and fresh water lakes. It has been found that the alkalinity of the lakes varies between rather great extremes, even the freshest of the fresh-water lakes being somewhat saline. Whatever may be the cause of this gradient in alkalinity, it is an obvious fact that the degree of alkalinity exerts a very powerful influence upon the vegetation. Studies are now in progress that will probably throw considerable light upon the power of certain species of plants and animals to adjust themselves to this varying chemical relation. In many of the more strongly saline waters scarcely any vegetation appears, although the beach may be well clothed with

[5] Pound and Clements.

rushes, sedges and salt-grasses. Frequently even the beach, many feet back from the water's edge, is so thoroughly impregnated with salts that they crystallize and form a white crust over the surface. This results in an absolutely barren zone. Back of that portion of the beach washed by the waves the salt-enduring plants develop very copiously. The salt-grass (*Distichlis spicata*) is usually controlling in such places where the low plants develop a very close tenacious sod. Beyond the belt of salt-grasses the taller stems of other grasses, sedges and rushes make up another distinct zone which may completely encircle the pond or lake. These plants are very dark green, so that the belts of vegetation about the saline lakes stand in marked contrast to the duller tones of the surrounding hills. Still farther back beyond the zone of tall plants the shore vegetation of the saline lake passes either abruptly or gradually into the typical wet meadow vegetation.

The appearance of the fresh-water lakes is quite different. First of all there is usually a wealth of submerged or half-submerged plants. Some of these lakes are literally filled with great masses of pondweeds (*Potamogeton, several species*), and the water milfoil (*Myriophyllum spicatum*). The bottom, in the shallower portions of such lakes, is covered with a carpet of stonewort (*Chara fœtida,* etc.), while the stems of the submerged flowering plants are richly coated with algæ of many kinds. In late summer certain of these algæ become broken away from their substrata and float about on the surface of the water. During high winds at this time great quantities of these, such as the net sack (*Clathrocystis æruginosa*), are washed on the beach in yellow green splashes. So there are many very interesting animals in the fresh-water lakes, a sponge being one of the common forms.

The white, encrusted beach is absent from the fresh-water lakes, as also are the belts of salt-enduring plants. The commonest marginal plant here is the great bulrush (*Scirpus lacustris*). Frequently this is the only plant between the bunch-grass association of the hills and the open water of the lake. Sometimes other species such as cat tail (*Typha latifolia*), and the giant reed grass (*Phragmites phragmites*) occur in mixture with the bulrush, or these may now and then form separate belts. Wild rice grass (*Zizania aquatica*) is a common marginal or shallow-water inhabitant of many of the lakes. This plant is about as tall as the bulrush, but because of its leafy stems it often forms much denser stands in the shallow water. When the seed is ripe every bed of wild rice is a Mecca for thousands of water fowl that live in the vicinity of the lakes. Wild ducks become so thick at times in these rich feeding grounds that the noise they make reminds one of an over-stocked barnyard.

The lakes range in size from small ponds to bodies of water one and

one half miles wide by five miles long. They vary in depth from four feet to probably about twenty-five feet. In many of the fresh water lakes the vegetation is encroaching upon the water, so that in time all of the lakes will have disappeared and wet meadows remain. The wet meadows of to-day show this sort of an origin very plainly. Many stages in lake eradication by invading vegetation may be seen in these lake regions. Some lakes are quite free from submerged aquatic plants; others quite free from bulrushes or wild rice; others show belts of these plants about the shore; in others the bulrushes have begun to wander

FIG. 13. SOME OF THE LAKES ARE SO STRONGLY ALKALINE THAT THE SALTS COAT THE BEACH WITH A WHITE CRUST.

into the deeper water, and in still older lakes the water can not be seen because of the complete occupation by the bulrushes and other vegetation. The bulrush is the commonest pioneer in this succession, and it is well fitted for this particular process. Oddly enough it is by the possession of the rhizome type of propagation, the very same character that fits *Redfieldia* for capturing the blow-out, that the bulrush is enabled to thus encroach upon the open water and finally to capture the lake. In the one case we have a species successfully eradicating a very dry, unstable habitat and in the other case a different species eradicating a very wet, stable habitat by identically the same means. The creeping rhizomes of the bulrush keep reaching into deeper water as the lake bottom is built up until other species are enabled to gain a hold back of the rushes. Thus other species follow in the wake of the bulrushes, and then come the common wet meadow species. At last the water is gone, the aquatic plants are gone, the bulrushes are gone, and the wet meadow plants have full possession of the former lake area,

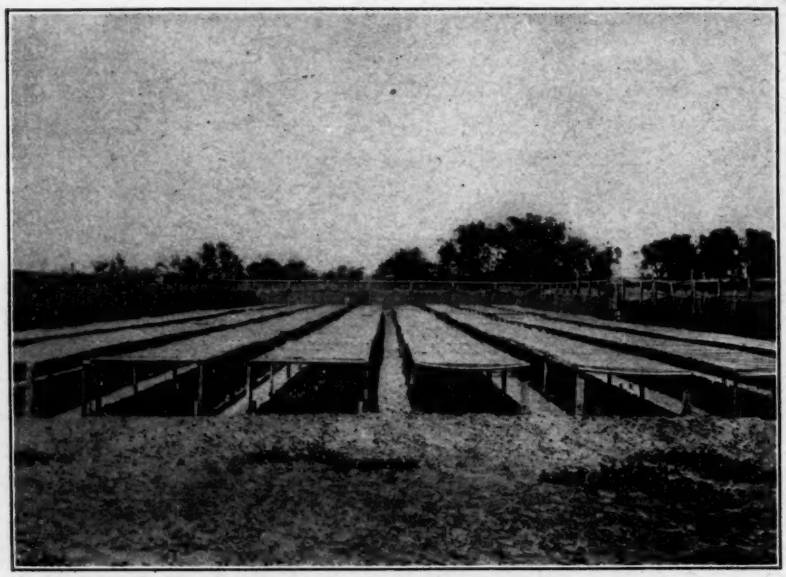


FIG. 14. A SECTION OF WESTERN YELLOW PINE IN THE GOVERNMENT FOREST NURSERY AT HALSEY.

and perhaps the stockman now mows his hay where once was open water.

The soil and climatic conditions over the Sand Hills as a whole are such as to fit this region in a peculiar manner for the grazing of immense herds of cattle. It is from the pursuit of this great industry that the region must always furnish its greatest returns. Thousands of cattle are annually shipped to the eastern markets from the Sand Hills. It is truly amazing to the "newcomer" to see how well the stock does upon what seems to be very meager forage. But with a well-kept range for the summer and plenty of hay for the winter the cattleman realizes a neat return from his labors. Those inhabitants who are so fortunate as to possess fertile valley land in addition to their upland range have made considerable progress along agricultural lines. The soil in many valleys is sufficiently fertile for the production of almost all of the common field and garden crops. Naturally because of the low acreage of agricultural land this industry will never reach great proportions. Alfalfa is destined to become the most important single crop in the Sand Hills. There are already many very good fields of this valuable plant. It is especially fitted to the soil conditions of many valleys, and when once established it resists the fury of the wind in a very encouraging manner. The success that has already been obtained by the early sowings should encourage other settlers to try it out very carefully.

Enormous crops of garden vegetables may be obtained from the river flats if the gardens are so situated that the land may be irrigated from

the river—and this is possible in a great many places. There are hundreds of acres on flats along the Loup River that could be made to yield high returns from truck crops. A small irrigation plant would cost but little, and the luxury of fresh vegetables would gladden the whole life of many a Sand Hill housewife who too often "digs" or "pulls" all of her garden truck from cans.

Much has been said and written about the possibility of covering the Sand Hills with trees. About ten years ago the U. S. Department of Agriculture, acting upon a suggestion from Professor Charles E. Bessey, made a preliminary examination of the region to determine if the conditions warranted an attempt at forestation. The examination resulted in the setting aside of about 80,000 acres in the worst portion of the hills between the Middle Loup and Dismal rivers as a national forest. The flats along the Loup afforded very favorable sites for the forest nursery, and, since it was thought best to raise the stock in the hills, a permanent station was established on the south side of the Loup about two miles west of Halsey in Thomas County.

In the spring of 1903 small jack pines were imported from Minnesota and these were set out on the hills. During this summer the forest nursery was started and from that time the Forest Service has continued to raise its own stock in its own nursery and every spring to plant

FIG. 15. THE PINE TREES DO BETTER IN THE MORE OPEN SAND THAN IN COMPETITION WITH THE GRASSES.

thousands of trees upon the hills. Naturally there have been mistakes and failures, but after almost a decade of active operations on the Dismal River National Forest one can not but marvel at the results obtained, if he is at all familiar with the extreme natural conditions that the government's experts have attempted to meet. The pine trees that were planted in 1903 are now about twelve feet in height and four inches in diameter. The bunch-grasses have been shaded out and a fine carpet of pine needles is beginning to accumulate beneath the green crowns of this young Sand Hill forest. So also, as I was able to demonstrate during the past summer, the temperature of air and soil, the humidity and evaporation, and the movements of the air in the vicinity of this plantation have been profoundly modified in comparison to those conditions in the bunch-grass association that completely surrounds these plantations. It is a most interesting and significant fact that the trees have adjusted themselves more readily to the fury of the wind on the hilltops and even in the blow-outs than to the struggle with other vegetation in the moister and more protected situations. Mr. Pierce, the supervisor of the Nebraska National Forest, told me in October that eighty per cent. of the trees planted in 1911 had passed through the summer drought and were making a brave effort to become permanent fixtures in the Sand Hill landscape.

The forest nursery established in 1903 has been enlarged from time to time until now it covers about five acres. When all of the seed beds are in use the nursery can care for about four million seedlings and two million transplants. The care of the delicate seedlings requires a great amount of skill and a large force of men in order that they may be kept free from disease and develop perfectly for the planting on the hills.

While it will be many years in the future before any return will be realized from this enormous experiment of the government's, yet the success of the first decade certainly warrants the continuation of the experiment. It is hoped that at some distant time acres of flourishing pine trees will grace many of the hills now so completely dominated by the bunch-grass.

The people of the Sand Hills are a hale and hardy lot. Their life is a rather hard one, even if they take advantage of every comfort possible for them. Many of them were lured by the roseate stories of the early "boomers" and came to the region from the east years ago. They found that the glowing tales of the wealth of the region were mostly florid falsehoods and that they were in a strange land whose productivity was not at all apparent and the rigors of whose climate were at times most severe. Many of these early homesteaders used up all of their capital in getting into the Sand Hills. Once there their disappoint-

ment was keen, but they could not return. They settled on the one-hundred-and-sixty-acre homestead, and during the first winter lived in a miserable, unhomelike dugout. In such a condition, poorly clad, without coal or other fuel in quantity, they braved that first terrible winter with its icy blizzards, the spring coming barely in time to save

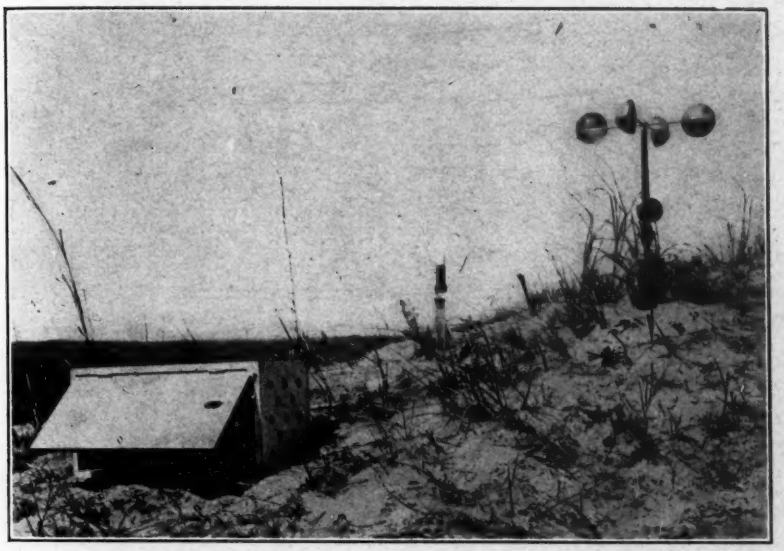


FIG. 16. INSTRUMENTS FOR THE DETERMINATION OF WIND VELOCITY, EVAPORATION, RELATIVE HUMIDITY AND TEMPERATURE.

them from an agonizing death. The next summer perhaps they built a small sod house into which were moved the few belongings, and then they began to map out plans for their future existence. There were neighbors in equally straitened circumstances, but after a while it was found possible to buy a few cattle and in this way a permanent livelihood was assured, and the foundations were laid for what is now one of the most important industries of the state.

The population of the Sand Hills is widely scattered. One may ride for twenty or thirty miles in almost any part of the hills and not see more than one or two houses, and frequently in such a ride he may not see a single home or meet a single person. The lack of human associates together with the monotony of the landscape and the slow routine of the lonesome day, the parching winds of summer, the call of the range, and the crimping blasts of winter, has left a telling imprint upon the homesteader and has made him a grizzled, fearless man. Far from the influence of the laws and the morals of civilization, he constructed his own statutes and his own code of morals. There were few entries here, but woe to him of the hills who lived not the life of an open book.

"A square deal for all" was the motto that the knights of this grassy kingdom wrote across their breasts. If a horse disappeared from the corral a hurried call was sent forth and a small mounted committee was soon scouring the hills. If the wrong man was found riding away astride the missing animal, he was jerked down, tried before this quickly constructed bunch-grass court, found guilty of horse stealing and was speedily strung up to a tree with a lariat rope, long before a single jury-man could be summoned in a region possessed of a "higher standard of

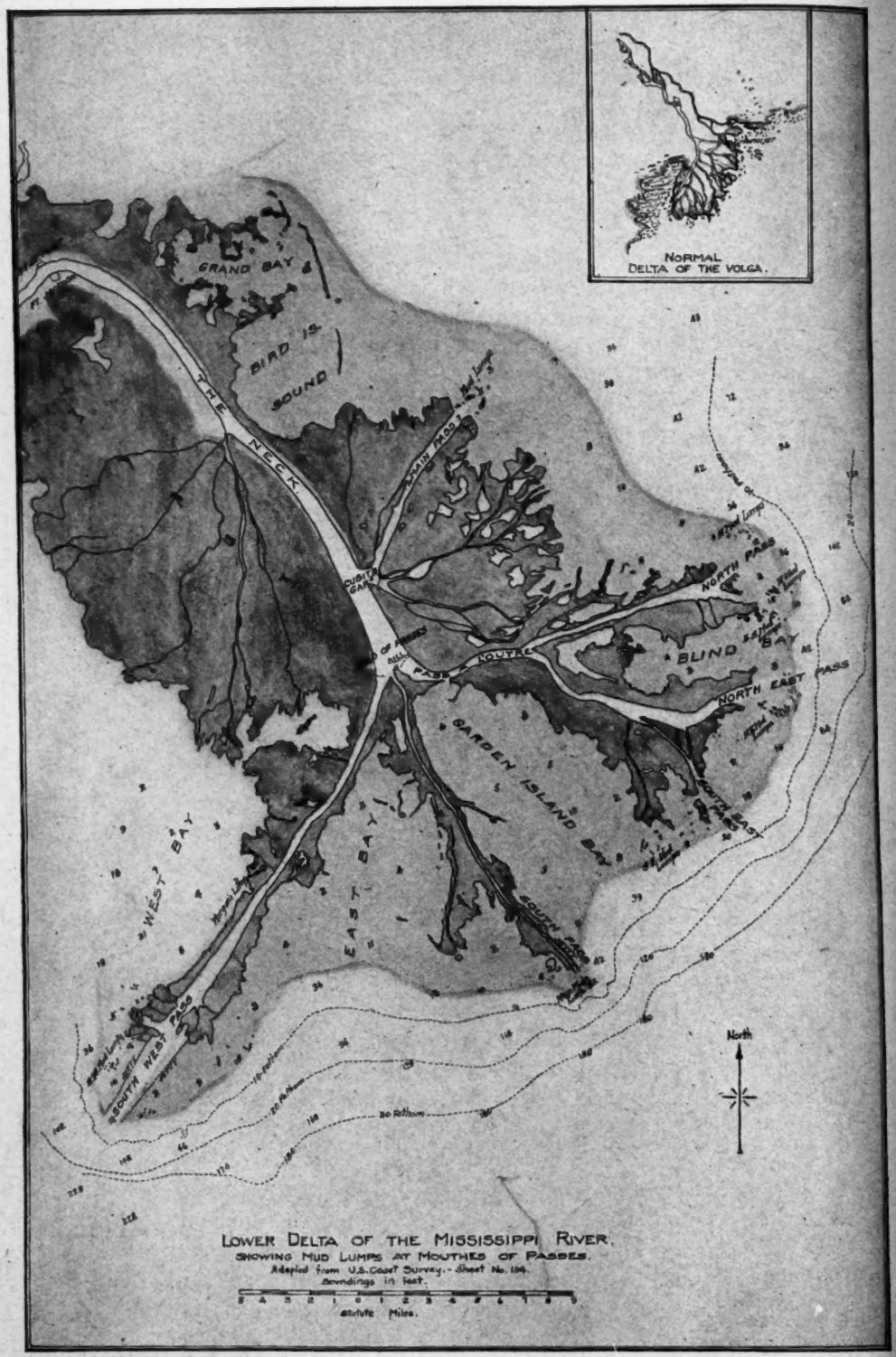
FIG. 17. THE DESERTED "SODDY" IS COMMON IN THE SAND HILLS.

ethics and a solemn regard for the law." Such was justice on the range, especially in the earlier days. Even in this late day the dove of peace does not nest in all the nooks of this great sand-hill domain. There is romance and chivalry of the real western sort in abundance. Only a few weeks ago four stalwart sons of the hills were sent to the state prison for life because of a deed that they thought was merely chivalrous. They went to the ranch house of a neighbor one night, took him from his bed, threw a rope over his head and pulled him up to a telephone pole. They had not intended to take the man's life, but simply sought to intimidate him and cause him to leave the country. He had made certain threats unbecoming to an inhabitant of the hills. He was allowed to dangle at the end of the lariat from the telephone pole too long, and as a consequence the four young men are in prison for the rest of their days.

From these statements the reader must not infer that life in the Sand Hills is dangerous or even uncongenial because of man's relation to his fellows. Naturally these people have individual rights which they

will protect with their lives, but to one who "lives in the open," no truer or more loyal friend can be found than in these rough men of the hills. Frugal, but hospitable to the extreme, they take great pleasure in the entertainment, in their humble way, of strangers who may chance among them.

Many of the homesteaders in this region after struggling along for a number of years, often facing death through cold or starvation, were compelled to relinquish their claims and leave the hills. So to-day one may find in many places the old dilapidated "soddy" and the scrubby, straggling timber claims of those who gave up the fight. On the other hand, many of those who managed to stay in the region have prospered. The sod shanty was for many years the characteristic habitation of the homesteader's family. This home was added to from time to time until a rather low, three- or four-roomed house of sod with plastered walls afforded much more comfort than the old conditions. At first the roof was also made of sod, but in later years the board or tar-paper roof has been substituted for the leaky sod. Those who have gone into the hills in the past few years and have taken claims under the Kincaid act have commonly built shacks of rough boards. Many of the older residents of the Sand Hills have lived for a number of years in very comfortable frame houses with most of the conveniences of the common farm house. Even the cement block has invaded the hills, and now there are numerous ranches with cement-block homes and round about the many other well-constructed buildings of the up-to-date ranch. Thus the development of the civilization and the architecture of the Sand Hills has passed through a number of periods in many ways as interesting and as remarkable as the evolution of the landscape and the vegetation of this great pasture domain.


NORMAL
DELTA OF THE VOLGA.
GRAND BAY
BIRD IS.
SOUND
THE NECK
MAIN PASS
NORTH PASS
BLIND BAY
NORTH EAST PASS
GARDEN ISLAND BAY
WEST BAY
EAST BAY
SOUTH WEST PASS
North
LOWER DELTA OF THE MISSISSIPPI RIVER.
SHOWING MUD LUMPS AT MOUTHES OF PASSES.
Adapted from U.S. Coast Survey. - Sheet No. 196.
Soundings in feet.
Statute Miles.

A NEW DEVELOPMENT IN THE MISSISSIPPI DELTA

By Professor E. W. HILGARD
UNIVERSITY OF CALIFORNIA

Introduction

In 1867 the writer was commissioned by the Smithsonian Institution to determine, if possible, the geological age and mode of formation of the rock salt deposit on Petite Anse Island, Louisiana. This involved, of course, a general examination of the coast formations of Louisiana, and among them, of the Passes of the Mississippi, and of the puzzling phenomena of "mudlump" upheaval in the Passes, which, at times, seriously obstructed commerce, but the origin of which remained a matter of conjecture. It had, to some extent, been investigated by Sir Charles Lyell (1858) and is commented upon in the tenth edition of his "Elements of Geology"; it was also conjecturally discussed by General A. A. Humphreys and other engineers connected with the Mississippi River Commission. My results, so far as the salt deposit is concerned, were published as Memoir No. 248 of the Smithsonian Institution; while the full report of my investigations of the Mississippi mouths and the mudlumps was published in the *American Journal of Science* in 1871–72.

As this work and its publication dates back so many years, and the latest publications on American geology and hydrography have wholly omitted any mention of it; and since a new phase of the subject has lately arisen confirmative of the views expressed and forecast made by me in 1872, it seems appropriate to recall that work to mind, and direct attention to the unfortunate fulfilment of a former prediction.

The Lower Mississippi Delta not a Normal One

The bird-foot shape of the lower Mississippi delta, with deep embayments in between, is unexampled in any other large river delta in the world. The bays between the delta-fingers ("Passes") are being very slowly shallowed, chiefly by wave and tidal action from the Gulf, carrying in the bar sands; *and only subordinately by river overflow.* The river in this lower delta region is for 50 miles below Fort Jackson bordered by narrow banks of unyielding gray clay, between which is carried the entire volume of the river through the narrow-banked "Neck," until it reaches a common point of divergence, the "Head of the Passes," whence similarly narrow-banked channels diverge, unbranched, in bird-foot form. (See the map accompanying this paper.)

The usual shape of a *normal* delta is a convex protrusion beyond the main shore-line, with usually slight protrusions at the mouths of the distributaries; as can be seen by an inspection of the maps of the deltas of any of the larger rivers, such as the Nile, Ganges, Brahmaputra, Danube, Volga, Lena and others. Within the delta-areas of these streams, large and small distributaries form a complex network, frequently changing at times of high water. No such changes are shown by the narrow-banked, diverging arms of the lower Mississippi delta, which steadily advance into the Gulf singly, and without any permanent distributaries being formed. The only approach to the form and structure of an ordinary delta occurs about three miles above the Head of the Passes, on the east side, where small and shallow channels connect with the main river through Cubit's Gap, a shallow lateral outlet.

Notwithstanding these facts, the Mississippi delta is figured in the latest edition of Chamberlin and Salisbury's extended work on geology, apparently as an example of a "*normal*" delta, and its formation is somewhat elaborately, but unconvincingly explained on the basis of the formation of the ordinary river deltas. The explanations do not, unfortunately, fit the facts as observable by any one examining the banks of the Mississippi Passes; nor is any mention whatever made of the existence and formation of the "mudlumps," which have proved of such vital importance to the commerce passing through the mouths of the Mississippi, that they have been called the "evil geniuses of the Passes."

Mudlumps

Considering that these mudlumps have for many years been known to, and discussed by pilots, navigators and United States engineers, and have been somewhat elaborately treated of by Lyell many years ago, it is remarkable that their existence, and the part they have so obviously played in the régime of the Mississippi Passes, should have been wholly ignored by writers on general geology, and even in the standard work of Russell on the "Rivers of the United States."

As my detailed investigation of the subject, made in 1867, is not even mentioned among the references given by Chamberlin and Salisbury, it seems proper to recapitulate that investigation in print, especially since recent events in the delta seem to have strikingly confirmed my results.

The Port Hudson Clay ("Blue Delta Clay" of former Writers)

The investigations of Humphreys and Abbott had established the fact that the sands and silts of the true Mississippi delta, at least from Baton Rouge to the mouths, are underlaid at comparatively shallow depths by a stratum of blue clay, 10 to 20 feet in thickness, practically impervious to water, and almost inerodable by water alone. This is

called the "blue delta clay" by Humphreys and Abbott; it will here be called the Port Hudson Clay, because it is entirely independent of the modern delta formation built up by the river.

In this stratum, when exposed in-shore or in shallow water, there frequently appear stumps of the deciduous cypress, suggesting that in former geological times a cypress swamp extended out gulfward, perhaps to the deep-water line at the edge of the continental shelf.[1] Beneath this Port Hudson clay stratum lie formations materially different, and of such a character, both physical and biological, as clearly proves them to be not river alluvium, but of marine, brackish and paludal origin. But these formations, as well as the Port Hudson Clay, have nothing to do with the present problems of the delta, beyond serving as the floor on which it is built forward. The depth of the sands and silts of the true delta is practically from thirty to forty feet, and rarely reaches above sixty feet. That so great a river should show so small a depth of alluvium, when compared with such rivers as the Nile, Ganges, Hoangho and others, at first appears incredible; but it becomes intelligible when considered in connection with the existence of the underlying Port Hudson clay stratum, and the extraordinarily rapid extension of the mouth of the river towards the Gulf; the advance of the bar at the mouth of the Southwest Pass being, at the time mentioned, about 340 feet per annum. That this advance, however, is not made by the usual process of delta formation, is clearly shown on the accompanying map of the mouths of the Mississippi, and the "normal" delta of the Volga.

Continental Shelf

As is well known, a continental shelf, covered by a comparatively shallow depth of water, runs out for about thirty miles beyond the present mouths of the Mississippi River, then breaks off into the deep waters of the Gulf. The original surface stratum of this shelf is the Port Hudson clay (the "blue delta clay" of Humphreys and Abbott); but it is now coming to be gradually covered with the delta deposits of river sediment; and it would be natural to connect the shallow-lying shelf with the unusually rapid advance of the river mouths.

It is not easy to see at first sight why even the existence of the Port Hudson clay stratum should interfere with the ordinary, merely con-

[1] In view of the many phenomena indicating that the present course of the Mississippi River is comparatively young, and that in times not far remote its waters flowed toward the Arctic Ocean, as contended by Professor G. H. Tight, such a condition of things would simply indicate a temporary cessation of an oscillation which, taking into consideration the deep submerged channels of western Louisiana and the present elevation of the Loess hills of Mississippi and Louisiana above the level of the river, as discussed by me (*Am. Journ. Sc.*, Vol. 48, November, 1869, p. 335) would amount to more than 800 feet.

vex form of the delta protrusion; nor why there should be the sudden diversion of the several main distributaries from one permanent point, viz., the Head of the Passes, and a failure of the Passes themselves to give out numerous minor distributaries, as is the case in all other known deltas.

Moreover, the existence of the "Neck," a single, narrow-banked channel carrying the main river from below Forts Jackson and St. Philip to the Head of the Passes without breaking through the narrow embankment into Grand and Bird Island Bays, is precisely analogous to the fingers of the lower delta.

Mudlump Clay

Even a cursory examination of the material causing this division and obstinately resisting the impact of the main current of the river at the Head of the Passes, shows that it is wholly distinct in character from the ordinary sandy and silty river sediment, and very different also from the Port Hudson clay; being a compact, impervious gray clay, and corresponding exactly to the material constituting the mudlumps. So long as it remains submerged or fully wetted, this clay resists erosion to a remarkable degree.

As we descend either of the Passes, an examination of their banks shows that these are formed of this same gray clay, and not of sandy or silty river deposit, which usually covers the clay only to the depth of a few feet. Hence, even a rise of the river does not wash out such lateral channels as Chamberlin and Salisbury speak of, connecting the river current with the adjacent bays. Even where such channels exist they have occasionally to be dug out by hunters or fishermen in order to reach the intervening bays, as they tend to fill up with the débris of mudlumps, and with river deposit. As we approach the mouths of the Passes, the banks are found to consist of small islets with small, shallow channels between, which, however, are also being rapidly filled in, progressively, partly by river deposit, but chiefly by disintegrated clay of the mudlump masses that have been raised above the water level. For when this clay of which the mudlump masses consist has been exposed to repeated partial drying and wetting, it crumbles into a loose mass, which is washed by rains into the shallow channels intervening between the mudlump islets and there settles into a mass very resistant to erosion.

Active Mudlump Cones

Still farther downstream we come, *in all but the South Pass,* to mudlump islets obstructing the channel, *historically known to have been upheaved from the river bottom,* and frequently exhibiting low cones from the apices of which there is a steady flow of semi-liquid mud,

accompanied by an occasional bubble of combustible gas. Remnants of such active mudlump cones have successively obstructed the Pass à l'Outre, its branch, the Northeast Pass, and the Southwest Pass. Rod soundings in active mudlump craters have reached a depth of 24 feet, but no solid bottom.

On measuring the proportion between the volume of gas and mud, I found the former to range from about one twenty-fifth to one thirtieth of the mud flow; the uniformity of which clearly indicates a steady pressure or *vis-a-tergo*. The mud flow, according to the universal testimony of river pilots, varies with the stages of the river, becoming much more lively at times of flood. Clearly, the gas is a wholly subordinate feature and not the *cause* of the mud flow; as has already been stated by Sir Charles Lyell. The latter attributed the ascent of the mud to the pressure of the sands and silts of the bar at the mouth of the Pass upon a *mud stratum lying beneath them and under the bed of the river,* the origin of which he, however, did not try to explain, but which is now to be considered.

Mud Layer Formed by Flocculation Beyond the Bar

My investigations of the peculiarities of colloidal clay, begun about 1869, led me to conjecture that the stratum of liquid mud was due to the precipitation of such clay from its diffusion in the turbid clay-water passing over the bar, by intermixture with the saline sea water; and that a layer of gelatinous, semi-fluid mud should, therefore, be found to seaward of the bar. That such is actually the case was proved by numerous reports received from pilots of sea-going vessels, who stated that at varying distances outside of the bar the sounding-lead begins to sink more slowly before it comes to a final stop on solid sea bottom, usually the Port Hudson clay. I could not obtain any definite estimate of the depth of the mudlayer, but the pilots said it might be from five to fifteen feet, according to the distance out from the bar.

I have, unfortunately, been unable to obtain an authentic sample of this mud from outside the bar. But of its existence there can be no doubt, and the huge scale upon which clay precipitation by flocculation occurs at mouths of all turbid streams emptying into the sea or saline basins, clearly shows that flocculation is certainly not the "limited and obscure" phenomenon that Chamberlin and Salisbury declare it to be ("Geology," Vol. I., p. 360). As the bar is built forward, the river sands and silts are spread on the mud stratum, so as to bury it under a broad cover. There would then tend to form on the surface of the mud stratum, by upward filtration, a thin but compact crust of tough clay constituting the bed of the river beneath the sands and silts which

are continually shifting with the current. Under this crust, however, the semifluid mud-stratum would remain, and would also underlie the river channel inside of the bar, on both sides of the channel, and farther upstream to an unknown distance, in one connected layer; and would be subjected everywhere to the pressure of the marshes and overflow materials.

Mechanism of Mudlump Upheaval

Taking the existence of this semi-fluid mud-stratum resting upon the Port Hudson clay and buried by the delta sands and silts throughout the lower delta, for granted, the mechanism of mudlump upheaval at once suggests itself; for the rapid advance of the heavy and extended load of river sands and silts of the bar over the mud stratum would not permit the escape of the slow-moving mud to seaward.

A striking confirmation of the presumption that the pressure on the mudlayer is exerted by the accumulation of sediment and vegetation in the marshes, and of the existence of the mud-layer itself even under the older marsh formation, is the occurrence of a large mudlump-cone in full activity in 1867, in the marsh seven miles above the mouth of the Southwest Pass, and between it and West Bay. From the Pass, it appeared as a slightly irregular conical hill, which, judging from the extent to which it projected above the highest reeds, was about 18 to 20 feet in height. A glittering mud stream on the south slope could readily be distinguished by the field glass. The lump was inaccessible at the time of my visit, but had previously been fully described from a personal visit by pilot Ben Morgan.

Mudlumps commonly arise in a channel or pass *immediately inside of the steep upstream slope of the bar,* in or alongside of the main current, where the depth is greatest, and where the bottom therefore can most readily yield. Soundings show that (doubtless owing to the impact and consequent scooping action of the river current as it is forced to ascend to the crest of the bar) there is nearly always a maximum depth just at that point, in the course of the main channel. This would seem to mean that as the weight of the superincumbent river sands and silts is thus relieved, the pressure of the great area of marshes lying upstream, of the delta deposits on either side, and to some extent, perhaps, the pressure of the bar itself, causes the upheaval of the river bed and in many, though not in all, cases produces an extrusion of the semi-fluid mud which is but slowly washed away by the current. The vents are formed near the water surface at first, but are then built up from the outflowing mud, which partly consolidates by loss of water, until small mud volcanoes, rising usually from three to four, but sometimes as much as twelve feet above the water surface, are formed.

A comparison of the mud ejected with that forming the narrow banks of resistant clay bordering the Passes, as above outlined, and also the same resistant clay banks at the Head of the Passes which cause their divergence, shows the materials to be undistinguishable. The conclusion is inevitable that the entire bird-foot delta at least, and doubtless also the narrow Neck in which the main river flows below Forts Jackson and St. Philip, are the outcome of the formation and destruction of mudlumps as the river progressed; and that these clay banks constitute the normal mode of progression of the emerged portion of the lower delta.

The extraordinary resistance of the mudlump clay, when once consolidated in the channel banks, to erosion by water, serves, together with the somewhat similar characteristics of the underlying Port Hudson clay, to explain the exceptional form of the lower delta of the Mississippi.

I should add that a microscopic, physical and chemical examination of the mudlump mud, and of the clay from the banks of the Passes, bear precisely the biological characteristics to be expected under the conditions outlined. There is an intermixture of fresh-water and brackish marine organisms; while the water forming the mud is manifestly sea-water in a condition of considerable dilution, and changed by maceration with the organic débris brought down by the river. As a result of such reductive maceration, the sulphates in sea-water have been largely eliminated in the form of minute crystals of iron pyrites, and the lime as carbonate; while the ratios of the chlorids have suffered little change. The details of this investigation are set forth in my paper in the *Journal of Science,* already referred to.

Eads's Proposition to Open the South Pass

In the early 70's of the past century, even the widest of all, the Southwest Pass, had become so obstructed by mudlumps that deep-sea navigation was very difficult to maintain, despite the most active dredging on the part of the government, and the construction of tugs of enormous power, designed to pull deep-drawing vessels through the upheaved mud. Captain James Eads, the builder of the St. Louis bridge, then conceived the idea that, as the South Pass was unobstructed by mudlumps, it might be made the main and permanently navigable channel if sills of willow mattresses were placed across the entrance of the other distributaries (the Southwest Pass and Pass à l'Outre), and if jetties were constructed at its mouth to maintain a current so strong as to carry away the obstacles caused by river deposits of all kinds. Accordingly, a bill was introduced into Congress for the construction of these improvements. When this came to my

knowledge, I wrote to Captain Eads calling his attention to my investigations of the Passes and of the origin of mudlumps, and suggesting that, *so sure as the main current of the river was turned into the South Pass, mudlumps would necessarily arise;* not at once, but within a period of probably twenty to thirty years. Captain Eads replied that, while he appreciated the force of my objection, even a surcease of twenty to thirty years would be of great service to American commerce, and that it would be unfortunate to bring the matter to public notice at that time. To this suggestion I agreed; and so soon as the bill passed Congress, the work was begun with his wonted energy by the distinguished engineer. He, unfortunately, died before its completion, but it was carried out according to his plans by his successors.

A Mudlump Appears in South Pass, Confirming Author's Theory

For about twenty-five years after the completion of the jetties there was little difficulty in keeping up the required channel depth of 26 feet, 200 feet wide in the South Pass and over the bar beyond the jetties. Within the last six or seven years, however, obstructions began to appear in the channel, which the dredges found great difficulty in removing and which, when removed, seemed to be promptly renewed at the original point. Within the last year it was definitely stated in the newspapers that the obstruction was a "mud bubble upheaved by the gas from the bottom of the river; the mud being so stiff that the dredges could not handle it, and a navigable channel had to be carried around it." I, thereupon, communicated with the engineers in charge of the South Pass navigation and promptly received, from Assistant Engineer C. Donovan, a blueprint of a map showing the soundings in the jetties, and beyond and across the bar; which, by this time, has become a pretty definite ridge, as in the case of the other Passes. This map shows that the current impinges directly against a mudlump mass which has arisen across its course, but has not yet reached the water surface; and a scrutiny of the soundings shows that a maximum depth exists, even now, right at the upstream slope of the newly risen lump. The highest portions of the mudlump are still about twenty feet below the water's surface; whether naturally, or kept so by dredging, I have not learned. No eruption of liquid mud has thus far been reported, although at such a depth it might easily have escaped observation.

Possible Forestalling of Farther Upheavals

This unfortunate verification of my prediction of the event would seem to confirm pretty definitely my theory of the origin of mudlumps in general. As this confirmation is of considerable interest for the

future of deep-sea navigation to New Orleans, I think it desirable to call attention to it at the present time, in order that, if possible, measures may be taken to prevent a still farther obstruction from mudlump upheaval, *by persistent cutting-away of the present lump as it rises;* so as to relieve the pressure at the point already upheaved, and thus, perhaps, prevent the rising of additional obstructions by giving vent to the mud column at the initial point. How far this is practicable I will not venture to discuss. It is an engineering problem of no mean difficulty, considering that, in past experience, the utmost efforts of specially constructed dredges have failed to maintain a proper depth for more than a few hours or days, where mudlump upheavals had occurred in the Southwest Pass. In the South Pass there has thus far been only a single upheaval to deal with, whereas in the Southwest Pass a succession of these upheavals rendered the maintenance of the main channel extremely difficult. When we consider that in many cases the shock of the grounding of a vessel on a mudlump was sufficient to cause a quick upward movement (in one instance lifting the bow of the vessel above the water over-night), showing a state of very unstable equilibrium, it is not at all inconceivable that in a comparatively narrow channel, as is the South Pass at the present time, diligent and effective dredging might serve to cause the upheaving force to continue to spend itself on the one point where it has now acted, and so to prevent, or at least retard, the formation of new upheavals.

It is to be noted that at the present time the dredges maintain, in the seaward channel, a depth of as much as thirty-seven feet. Whether this depth, apparently excessive for the present requirements of navigation, will prove an incitement to new upheavals of the bottom is, perhaps, a question worth considering. In any case, the mudlump now lying across the mouth of the main channel of the Mississippi has doubtless come to stay, and no amount of dredging will suffice to do away with it.

THE IMPERIAL UNIVERSITIES OF JAPAN

By H. FOSTER BAIN
SAN FRANCISCO

THE public school system in Japan, as in the United States, is capped by the university. In keeping, however, with the highly centralized government of the former country, the university is controlled and supported by the imperial government, whereas in America the support of higher education has been left so far to the individual states. The imperial government now maintains two fully organized universities; one at Tokyo, and a second at Kyoto; and is organizing two more; one in the south at Fukuoka, Kyushu, and the other in the north at Sapporo, Hokkaido. At Fukuoka, medical and engineering schools have been established and others are to be added. At Sapporo only an agricultural station and an agricultural college, which go back to early American influences, are as yet in being, though the plan contemplates ultimately a complete university. In addition to these imperial schools there are important institutions of university rank endowed and supported by private initiative, and in this as in other particulars the situation shows similarities to that in the United States. Among these non-governmental schools Waseda and Keio are the largest and best known. What is said here relates exclusively to the Imperial Universities of Tokyo and Kyoto, limitations of time having prevented my visiting the others.

With the beginning of the new era in 1868, Japan faced the problem of organizing a new system of education, as well as of government, war and industry. Previously there had been no general system of public instruction, and in this, as in many other particulars, the work was essentially one of construction rather than re-construction. It would be a grave mistake, however, to consider the Japanese of the pre-Meiji eras as uneducated. While not familiar with Western learning, they were far from unlearned, and in the sense of having had their mental powers developed many of the gentlemen of old Japan were highly educated. This was especially true of the younger sons of the daimyos who, forbidden by the social system to marry or hope for headship in their own houses, were driven to the exercise of arms and rigorous study of the Chinese classics, each hoping to attract attention and be adopted as heir in another house. Failing in this, many opened private schools. In these, and other institutions whose origin is too diverse to permit review here, a severe drill in the Chinese language and literature and in Oriental philosophy, gave to the pupils a mental training not greatly dissimilar to that which our own grandfathers

received from the study of "Greek, Latin and Philosophy," in the early American colleges. When studying the rapid progress of Japan in the acquirement of western science, it is more nearly correct to think of men with B.A. and M.A. degrees derived from the study of Greek, taking to engineering, than to think of a wholly uneducated people suddenly turned loose to browse in the whole field of knowledge. Indeed, in the later days of the Shogunate, Western knowledge had already begun to penetrate the hidden country. Books brought in by the Dutch and translated into Japanese, by scholars working as did our own when first deciphering the hieroglyphics of Egypt, had a large influence if small circulation. Soon after the visit of Commodore Perry, the Shogun established in 1857 an institution for the translation of foreign books, which by easy transition became first a school of foreign languages and finally a component part of the present Tokyo Imperial University. Similarly the medical school of the university had its roots in the Seiyo Igakujo, established under the Shoguns. In the early years of the Meiji era there was a bewildering succession of organizations and reorganizations in the higher educational institutions as in other branches of the public service, but with the issuance of Imperial Ordinance No. 3 (March 1, 1886), providing for the organization of imperial universities, the institution in Tokyo took essentially its present form. In 1890 an existing agricultural college there was consolidated with the faculties of law, medicine, engineering, literature and science already organized. In 1897, with the establishment of the sister institution at Kyoto, the name was changed from Teikoku Daigaku, or Imperial University, to its present form, the prefix Tokyo being added to indicate the place of its establishment.

The imperial ordinance already mentioned is a remarkable document, warranting careful attention from educators. It evidences a close study of existing universities and their fitness to the needs of the people in both Europe and America, and a nice critical sense in the selection of those features best suited to conditions in Japan. In it, as throughout contemporary Japanese institutions, there is at the same time the germ of new things, for Japan is far from being content to adapt, and purposes to originate as well. The object of the imperial universities is stated to be "the teaching of such arts and sciences as are required for the purposes of the state, and the prosecution of original research in such arts and sciences." This article foreshadowed concisely and accurately what has become the essential characteristics of the great universities that have been established under the ordinance. Essentially the schools were to be, and are, sources of information rather than devices for mental training. They had for their field all knowledge "required for the purposes of the state" and were to be frankly utilitarian branches of the government. This, however, was not to be, and has not been, interpreted in any narrow spirit since—and in this

America may well take a lesson—research as well as instruction was to be regarded as equally the function of the university. Emphasizing the latter point, the second article provides that "Each imperial university shall consist of a university hall and colleges; the university hall being established for the purpose of original research, and the colleges for instruction, theoretical and practical." These purposes and ideals have been faithfully followed in the organization and work of each of the universities. Subsequent ordinances have provided for the financial support of the institutions and have specified the number and rank of officers and instructors; several independent government institutions, such as the Tokyo Astronomical Observatory, the Marine Biological Station, and the Botanic Garden have been added to the university; regulations as to degrees have been made, and additional facilities have been provided; but the fundamental character of the universities remains as fixed in the ordinance of 1886.

In Tokyo Imperial University there are now six colleges: those of law, medicine, engineering, science, literature and agriculture, and University Hall; the latter the research institution. At Kyoto the school, being younger, is less completely developed, the colleges being those of law, medicine, literature, and science and engineering. Here, as at Tokyo, a university hall also provides for research or graduate studies, as that term was used twenty years ago in America before post-graduate work became so formalized. The term college, as used in Japan, does not correspond exactly to usage either in England or America. The college is more nearly a "faculty," as that word is applied in the larger American schools. Each college is presided over by a director and each controls, through a faculty meeting, the curricula, examinations and qualifications of candidates for degrees. The faculty must also hold itself in readiness to consider educational or technical questions submitted by the minister of education and hence becomes an official adviser of the government on matters within its field. The directors of the various colleges, together with one professor from each, constitute the university council, presided over by the president. This council may consider questions relating to the institution or abolition of a course of study in any college, questions relating to chairs in the universities, regulations for the internal government of the institution, granting of degrees, and may suggest modifications of imperial ordinances, and of regulations by the minister of education relating to the university. The council also must, on request, advise the president or the minister of education. The president, who is appointed directly by the Emperor and ranks with a cabinet officer, has general control of the affairs of the university and, as in America, has large powers. Baron Kikuchi, the president of Kyoto University, and formerly holding the same position at Tokyo, has been minister of education and has rendered distinguished service to the state in many ways. Baron Hamao, presi-

dent of Tokyo Imperial University, was one of the pioneers of modern education in Japan and a man of great ability and influence. Such men would wield power under any system, and in Japan full advantage is taken of their abilities. The power of the president, however, is sharply limited in certain particulars where in America it is possibly too often unchecked. For example, professors are appointed by the minister of education, but "in each case that professor shall be appointed who shall have been chosen at an election held by the professors of his particular college." Professors, while not well paid in Japan, occupy a position of much more importance and dignity than in America. They are elected for three years, but may be, and are, reelected indefinitely. They receive only from $600 to $2,000 per year, but this is relatively much more than the equivalent sum in America, and they have a pension system, are paid part salary when relieved from duty for any reason, are given periods of leave of absence, are sent abroad for study in rotation, are intrusted with important government investigations at home and missions abroad, and are treated with every courtesy and respect. It is one of the curious contradictions met constantly in Japan, that in an empire a man of title gets less recognition and a university professor more than in the United States. It is true that in Japan, as in America, the professor must console himself with the honor for the inadequacies of his salary. Both that and traveling allowances are small when measured against the cost of living. Engineering professors, at least—I can not speak as to others—derive supplementary income from consulting work, though there is a strong public opinion which prevents this from degenerating into a mere scramble for dollars.

Professors, while poorly paid in Japan, are relatively numerous. At Tokyo the instructional staff consists of 6 directors, 156 professors, 93 assistant professors, and 110 lecturers; a total of 356. In addition there is an elaborate staff of university officers. At Kyoto, aside from these general officials there are 4 directors, 85 professors, 53 assistant professors, and 41 lecturers; 183 in all. Certain peculiarities of Japanese university organization will be illustrated by listing the professors in two of the colleges of the University at Tokyo. For convenience the College of Law and the College of Engineering may be chosen. In the former they are: Constitution, 1; public law, 1; civil code, 4; commercial code, 2; maritime law, 1; code of civil procedure and law of bankruptcy, 2; criminal code, 1; code of criminal procedure, 1; political economy, 5; finance, 1; statistics, 1; politics, 1; history of politics, 1; diplomatic history, 1; colonization, 1; law of administration, 2; public international law, 2; private international law, 1; history of legal institutions, 1; comparative history of legal institutions, 1; Roman law, 1; English law, 1; jurisprudence, 1. In the College of Engineering the list of professors includes: Civil engineering, 4;

mechanical engineering, 3; naval architecture, 3; marine engineering, 2; technology forms, 2; electrical engineering, 3; architecture, 3; applied chemistry, 4; technology of explosives, 1; mining, 2; metallurgy, 3; applied mechanics, 1; dynamics, 1; a total of 32. In addition, students in each college take courses in other colleges, so that the effective faculty is largely increased. Geology, for example, is taught to students in mining and engineering, by the professors in the College of Science.

In examining these lists the reader will probably be struck first with the breadth of the instruction given. For example, in no American law school of which I know is it possible to take courses in three systems of foreign law, and in America political economy and the related group of subjects would be taught by a separate faculty instead of as part of the law course. In Japan as in America, a law course is the common preparation for many branches of the public service, but in the former country only is that fact recognized by placing under charge of the faculty of law the whole of the instruction in politics and public affairs. The Japanese are an intensely practical people, and this is one instance of their regarding university education from the utilitarian standpoint—using that word, I repeat, in a broad sense. The same disposition is shown in the College of Engineering. Provision of instruction in naval architecture, technology of arms, and technology of explosives, is not common in American universities. It is the more striking since Japan maintains a separate school corresponding to our own West Point for training army officers, and others for preparing officers for the navy, the railway service, and even for educating officers for the merchant marine. University instruction in these branches is of a higher type than in these special schools, and is more closely related, through University Hall, with research. Another peculiarity is the provision of several professors in the same subject. In Japan there is more democracy and less organization within each department than in the United States. There are coordinate professors, each perhaps with his specialty, rather than a rigorous system of head professors, professors, assistant professors, assistants and so down to the *n*th order. Still another instructive feature of the system may be seen by examining the courses in some one department. For that purpose those given in mining and metallurgy at Kyoto may serve. It will be noted that the courses provide for what in the United States would be considered undue specialization and make almost no provision for fundamental training. It is true that Japanese students are supposed to have this before taking up their university work and have in fact much better opportunity for acquiring it than have American students. One may none the less retain a doubt whether in this case practise and theory run hand in hand.

MINING AND METALLURGICAL COURSES AT KYOTO

	Hours Per Week	Time
Mineralogy (Lect.)	3	4 months
Mineralogy (Exerc.)	2	1 year
Geology and lithology (Lect.)	2	1 year
Geology and lithology (Exerc.)	1	
Ore deposits (Lect.)	2	1 year
Surveying (Lect.)	2	4 months
Surveying (Exerc.)	3	
Mine surveying (Lect.)	2	4 months
Strength of constructions (Lect.)	1	1 year
Strength of constructions (Drawing)	2	
Factory architecture (Lect.)	2	6 months
Outlines of mechanical engineering (Lect.)	3	1 year
Outlines of electrical engineering (Lect.)	2	1 year
Mining, parts I. and II. (Lect.)	4	1 year
Mining, part III. (Lect.)	3	1 year
Mineral dressing (Lect.)	2	1 year
Briquetting (Lect.)	2	2 months
General metallurgy (Lect.)	2	1 year
Special metallurgy, parts I. and II. (Lect.)	5	1 year
Electro-metallurgy (Lect.)	2	6 months
Iron metallurgy (Lect.)	3	4 months
Iron metallurgy (Lect.)	2	6 months
Mechanical and metallurgical technology (Lect.)	3	6 months
Metallography (Lect.)	2	2 months
Assaying (Lect.)	1	1 year
Assaying (Exerc.)	3	
Blowpipe analysis (Lect.)	1	6 months
Blowpipe analysis (Lect.)	3	
Mining laws (Lect.)	2	6 months
Drawing, part I.	6	1 year
Drawing, part II.	6	1 year
Chemical analysis, part I.	10	8 months
Chemical analysis, part I.	15	2 months
Chemical analysis, part II.	10	4 months
Chemical analysis, part II.	9	6 months
Metallurgical experiments	6	2 months
Iron metallurgical experiments	4	2 months
Electro-metallurgical experiments	3	2 months
Experiments for mineral dressing		2 months
Practise in mine surveying		2 months
Practise in mine surveying works		4 months

The special courses noted are given by a faculty consisting of 4 professors, 4 assistant professors, and 1 lecturer; assisted by 2 professors from the College of Law. A few are given in the civil or electrical engineering departments, being required of or open to election by students in mining. At Kyoto the faculty of the Institute of Mining and Metallurgy consists of Professors Jisaburo Yokobori, Daikichi Saito, Viscount Tadashiro Inouye, Toshio Watanabe, all graduates of the

Tokyo Imperial University with doctorates obtained in engineering. In addition Dr. Yokobori studied two years at Freiberg; Dr. Saito, one year each at Freiberg, Aachen and Columbia; Viscount Inouye, three years at Freiberg, Berlin and other German schools, followed by two years in practise in the United States; and Dr. Watanabe, whose specialty is electro-metallurgy, three years at Aachen. Dr. Oda, who gives instruction in mining law, and Dr. Kambe, who lectures on industrial economy, are also graduates of the university at Tokyo, as is Mr. Tadasu Hiki, the instructor in geology, and Mr. Kenroku Ide, who has been sent abroad to study metallurgy. Mr. Tetsujiro Imanaga, and Mr. Shoji Takahashi, assistant professors, instructing respectively in mine surveying and metallurgy, are graduates of Kyoto Imperial University in engineering, who have not yet proceeded to the doctorate. Dr. Yamada Kunihiko, who instructs regarding ore-deposits, though listed as lecturer in mining, is a graduate of Tokyo with two years later experience at Freiberg. The director of the College of Science and Engineering, to which the Institute of Mining and Metallurgy belongs, is Dr. Mitsuru Kuhara, who obtained his degree at Johns Hopkins for work in organic chemistry.

Formerly, Tokyo University was largely manned by foreign professors. At present there are but 14 foreigners in the whole faculty. At Kyoto the entire faculty is Japanese except 1 French, 1 German, 2 American, 1 Chinese and 1 English lecturer. There has been some disposition to criticize the promptness with which the Japanese dispensed with the foreigners, but there can at least be no question that they have been replaced by well-trained men, and in view of the imperative necessity for economy, the move was not unnatural. As it is, nearly five per cent. of the faculty at Tokyo consists of foreigners (not counting emeritus professors) and the great majority of the instructors both at Tokyo and Kyoto have studied abroad, following courses at home roughly equivalent to that which leads to the Ph.D. degree in a first-class American university. At the time when in the United States our universities were copying most directly and actively after those of Germany, there were few professors imported from that country. We sent rather our own men to Germany to be instructed, and when they returned the movement of students abroad largely ceased. Japan has followed our example, except that she still continues to send her men abroad for final instruction if they are to be entrusted with the higher posts in the university.

A university without students is but a simulacrum, and doubtless the reader has begun to wonder about Japanese students. It is first to be noted that they are all men—for in Japan coeducation does not obtain above the elementary schools. Japanese children begin their schooling at six and for the next six years education is compulsory. It is confined to the elements of language, mathematics, nature study,

morals, geography and history and is given in Japanese. At present 96 per cent. of the children of school age are in school, and the records for attendance and proficiency are enviable. Beyond the age of twelve the boys and girls separate, but, contrary to American experience, it is the girl rather than the boy who drops out or is kept at home. The demand for instruction has from the first far outrun the financial ability of the Japanese government to provide and from the elementary school up there are more applicants than can be admitted. In general selection is made on the basis of efficiency, and competitive examinations are the usual means. The boy who, therefore, at the age of 22 or 23 finally reaches the university after passing through middle and higher schools, is the one left by a long process of elimination. It would be interesting to follow the boy through this course, but the limits of this article forbid. Those interested will find the elementary, middle and higher schools, excellently described by Baron Kikuchi, in his most instructive and readable book "Japanese Education."[1] It is sufficient to state that the student comes to the university with long training in English and one or more other languages and with about the mental training and culture that American students have when they enter the junior year of a first-class university. He is ready to specialize, has in fact prepared to specialize, and has received his training in how to study. The university course is therefore concerned more with subject matter than with method. The course is three years long and at its completion the student is entitled to assume the title of *gakushi* in law, medicine, science, engineering, or whatever line he may have followed. This, it may be noted, is not a degree conferred by the university, though roughly equivalent to our own bachelor's degree. Upon attaining to this rank the student is ready to study for the doctorate, for which five years work in University Hall is required. During the last two of these years he may, under certain restrictions, engage in practise away from the university, and before becoming *gakushi* he must, in engineering at least, spend six to eighteen months in practical work. In the latter case he is sent to a mine, smelter, or other works, and required to follow a prearranged course, reporting to the university on each piece of work as completed and receiving meanwhile help from the university, much like that given to students in correspondence courses in the United States. While in this preliminary practise he is not allowed, except by special agreement, to receive pay; the object not being to put the student into regular work on a money-making basis, but to permit him to learn practise in a commercial plant. The university reserves for its own field the teaching of principles.

Degrees are not given by the university, but by the Minister of Education upon proper recommendation. This may come either from the university or by a two thirds vote of the assembly of *Hakushi*, those

[1] John Murray, London, 1909.

graduating with the doctor's degree, of each school. The degree may be given either for completion of the regular course or for a satisfactory piece of research conducted under the auspices of University Hall. To the latter admission is either by graduation from the university with *gakushi* rank or by examination. Thus the way is open to the highest degree for the non-college trained man who is capable of doing research work and satisfies the faculty, or the graduates, as to his ability. This provision for the exceptional man is, I believe, especially commendable and stands in contrast with the growing tendency of universities in the United States to standardize everything. Degrees in Japan open the way to appointments on the bench, in the civil service, and to responsible positions in mercantile life. They are, therefore, much in demand, and there are always many more applications for admission to the universities than can possibly be accepted. At Kyoto there are now 984 students, of whom 70 are in University Hall, or, as we should say, are graduate students. At Tokyo there are over 5,000 students and there are now nearly 10,000 alumni. Of 5,737 admitted in the years 1905 to 1909, inclusive, 1,076 were graduates of the colleges, 4,709 came from the higher schools, and 1,029 were admitted by examination. Of those who enter the university a large number remain to graduate. At Kyoto the proportion is 70 per cent.; a sure test of the quality both of students and professors, though passing standards in examinations are low, 60 being a passing mark. If, however, one may judge by a very brief experience in meeting university men in Japan, few who are unfit survive. Degrees in Japan have one further peculiarity. They are revocable for anything which involves moral culpability. The *Hakushi* have the power of revoking as well as recommending degrees, though a three fourths vote is necessary for that purpose.

The University at Tokyo supports no dormitory, and at Kyoto most of the students lodge outside the grounds. They, as in the lower schools, wear uniforms and pay moderate tuition fees. Professor Basil Hall Chamberlain, speaking from his long experience says: "As for the typical Japanese student, he belongs to that class of youth who are the schoolmaster's delight—quiet, intelligent, deferential, studious almost to excess. His only marked fault is a tendency common to all subordinates in Japan—a tendency to wish to steer the ship himself." To the stray visitor Japanese students seem much like those in America. Their actual greater age is not apparent, since in Japan nobody looks as old as he is. They are generally sturdy, well set-up looking, young men. Formerly they devoted too little attention, it is said, to physical culture, but the introduction of gymnastics, changes in diet, and the introduction of sports has worked wonders. A professor in the University of Tokyo struck an answering chord when he remarked to a group of American visitors, "Yes, the campus is very beautiful—but it is not

large enough for baseball!" The latter bids fair to become the national game of Japan as it is of the United States, young Nippon taking to it as readily as does young America. In adopting the game the Japanese have also adopted the American nomenclature so that cries of "Ball two, Strike one" and "Out at first" are heard on campus and sand-lot on both sides of the Pacific. Military drill, compulsory through middle and higher schools is not, I believe, required of university students, though they show in their bearing the effects of their previous training. Those who, while in the university, become subject for military duty are excused until they complete their studies. They are also required to serve but one year and become eligible for positions as officers.

In equipment the imperial universities are excellently provided, but in lands and buildings, judged by lavish American standards, they are not so well fixed. At Tokyo the university stands within the grounds of Kaga Yashiki, the former residence of the Daimyo of Kaga, who gave the property to the government for the founding of the school. The club house is one of the old residence buildings of the Daimyo and is surrounded by a bit of landscape gardening that no art or money could reproduce without the element of time that entered into its making. Adjacent to the university is the home of the present Marquis, a part of the original holdings having been retained by the family. The buildings of the university are unpretentious, but well-planned and well-built brick structures. There is a central power station, water and sanitation have been well cared for, and for working plant the university is well provided. The same is true at Kyoto, though at both places money has been spent on men, books and apparatus rather than on buildings. The library at Kyoto consists of 255,000 volumes and that at Tokyo of about 240,000 Japanese and Chinese books, and 189,300 European and American. As Tokyo University is charged with the duty of compiling the historical records of Japan, the collection of native material is certain to increase rapidly in amount and value.

Both Kyoto and Tokyo universities support learned publications in literature, science and arts. The publications of the Medical School at Tokyo are in German, those of the Observatory in French, and the others in English, except the republication of documents relating to Japanese history, a monumental work in Japanese. The list of titles at Kyoto and at Tokyo reads not unlike similar lists from Johns Hopkins, Columbia or Chicago. As for doctor's theses, they read alike around the world, but one wonders what Shinjo Sogo, who obtained the coveted Hogakushi by investigating the subject, found to be the "Fundamental Ideas of Political Economy," and also what Naoji Oshina, Bungakushi, resolved on as the "Theory of the Moral Ideal." The study of the "Development of Pure Philosophy in India," by Taiken Kimura, should also be of interest. With the abundant materials available and the insight given by favorable historical background those who devote them-

selves to the study of eastern philosophy ought to develop results of wide value.

For the historical investigations and other special duties intrusted to the universities, such as agriculture experimentation, forestry work, support of a marine laboratory, and similar duties, funds have been provided which, while inadequate, must be conceded to be large in view of the ratio of demand to supply in the national exchequer. For general support of the universities an annual appropriation of 1,358,838 yen ($679,419) is made to Tokyo and 840,000 yen ($420,000) to Kyoto, These funds are supplemented by special appropriations, fees, donations, and income from endowment. The total sum available at Kyoto for 1911 was $728,902. Small as this amount is in proportion to the work that can be done, no one can visit the Japanese universities without being deeply impressed with the strong hold they have on the interest of the nation. A reading of the list of benefactions and endowments at either institution makes clear that this affection is bounded by neither class nor section. Scholarships and special aid funds have been established by banks, by mining, shipbuilding, and mercantile companies, and memorial scholarships of all ranks of importance have been provided. The amounts are not large, $100 to $500 being most frequently mentioned, though both larger and smaller sums have been given. With the inevitable fall in interest rate the value of the individual gifts is bound to decrease, despite careful regulations for repayment of money advanced from them. The spirit, however, that they reflect, and which at the same time they foster, will become increasingly valuable. It is this that has made Tokyo a great educational center which will more and more attract special students from all over the world. It is the inevitable result of the whole-hearted cooperation of the Emperor, the government, and the people, both rich and poor, who are earnestly working to give to beloved Nippon the best there is in education as in other things.

EFFICIENCY WAGE STANDARDS

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EFFICIENCY, when applied to personal capacity, signifies a maximum of return with a minimum of outlay; hence one man is more efficient than another if, with a given expenditure of energy, time, raw material or capital, he can secure a larger, though equally good, product. The term efficiency is thus purely relative, since there is no known limit to human possibilities.

Each progressive employer aims to promote the efficiency of his working force, for unless he secures a maximum return in product for a minimum outlay of administrative ability, he himself is inefficient. That manager who, other things being equal, produces the highest net return for his outlay is looked upon as the most efficient manager. Yet in producing this outlay no one factor plays a more important part than the efficiency of the labor force which the manufacturer has at his command. How then can he increase this labor efficiency? How insure a maximum productive power among his workers?

Several attempts have recently been made to answer this question practically and definitely by inquiring, "How much money is necessary to maintain an efficiency standard of living?"—that is, how much money is required to supply food, clothing, housing, education, recreation and the other necessaries of life in sufficient quantities to enable the recipient and those dependent upon him to maintain normal health, strength and intellectual acumen. A successful answer to this question will, in a measure, enable the employer to gauge the efficiency possibilities of his labor force.

Several very careful studies have recently been made, which are remarkably uniform in their conclusions as to the amount necessary to maintain efficiency in the various cities under consideration. Of these studies, by far the most exhaustive is that made in New York City in 1907 and 1908.[1]

An analysis of the family budgets of four hundred workingmen, together with an exhaustive study of food values, housing, clothing and the like, led to the conclusion that: "An income of $900 probably permits the maintenance of a normal standard, at least so far as the physical man is concerned. . . . Whether an income between $800 and $900 can be made to suffice is a question to which our data do not warrant a

[1] "The Standard of Living among Workingmen's Families in New York City," Robert C. Chapin, New York: Charities Publication Com., 1909.

dogmatic answer."[2] The family to which these conclusions referred is a "normal" family, consisting of a man, wife and three children under fourteen years of age.

In the same report appears an analysis of one hundred workingmen's families in Buffalo, with the conclusion that before they were applied to Buffalo, the New York figures should be reduced by $150,[3] and this estimate is probably confirmed by a later Buffalo study.[4]

In Homestead, a suburb of Pittsburgh, a recently completed study covered ninety-nine families, from whose budgets the investigation concludes: "It is not until we cross the $20 (a week) mark that we feel that the family is well provided for and need, if provident, have no fears for the future."

A report of the Maryland Labor Bureau contains the following statement relative to Baltimore: "A family of six living in any large American city on less than $1,000 will wear neither diamonds nor velvet, nor will their children get the benefits of high schools nor technical colleges; indeed, they will not have more than the necessities of life."

The available authorities are, therefore, in practical agreement that an efficiency standard of living can be maintained in the cities of the Middle States on from $750 to $900, varying with the family, the nationality and the city. Accepting these conclusions as a basis for further argument, we must next inquire how the wages actually paid compare with this efficiency standard, since the relation of workingmen to efficiency standards is, in the last analysis, measured by the wages which they receive.

How many men earn from $750 to $900? In other words, how many workmen receive sufficient wages to enable them to rear three children, give them enough nourishing food, warm clothes, a decent house, an education to their fourteenth year, and a legitimate amount of recreation? An answer to this problem is best sought in the able statistics of American wages.

The available statistics of classified wages, which are, in the last analysis, the only really valuable wage statistics, permit of conclusions regarding the wages paid to both males and females. The following table, containing a brief summary of the available data on the wages of adult males, furnishes the most accurate available answer to the question "What are wages?" For brevity, the table covers only five income groups, for each of which the cumulative percentages are set down. Throughout the table, these statistics are remarkably uniform. About one half of the adult males receive less than $12 per week ($600 per

[2] Supra, p. 246.

[3] Supra, Appendix V., prepared by John R. Howard, Jr., pp. 315–17.

[4] "Decencies which a Laborer's Wage Denies," Frederic Almy, *The Survey*, Vol. XXIV., p. 368 (June 4, 1910).

CUMULATIVE PERCENTAGES OF MALES RECEIVING CERTAIN CLASSIFIED WEEKLY EARNINGS. COMPILED FROM CERTAIN REPORTS 1908–1910

Classified Weekly Earnings	Massachusetts,[5] 21 Years and Over	New Jersey[6] 1909, 16 Years and Over	Kansas 1909,[7] 16 Years and Over	Wisconsin[8] 1906–7, All Males	Bethlehem Steel Works[9] 1901, All Males	Railroads[10] of the U. S. 1909, All Males
Under $ 8.....	12	18	8	12	8	22
Under 12	52	57	46	59	60	51
Under 15	72	74	70	89	75	78
Under 20	92	91	91	98	92	92
$20 and over	8	9	9	2	8	8
Total employed..	350,118	204,782	50,720	128,334	9,184	1,502,823

year); while less than one tenth receive wages of more than $1,000 per year. All of the reports, therefore, present a remarkably uniform picture of the wages of adult males.

Here, then, is an effective answer to the question, "What are wages?" A study of the above table shows that half of the adult males working in the industrial sections of the United States receive less than $600 per year; three quarters are paid less than $750 annually, and less than one tenth earn $1,000 a year. These figures are not accurate, however, since they are all gross figures, including unemployment. They should be reduced by, perhaps, 20 per cent.,[11] since that reduction would make all due allowance for unemployment, varying with the year, the location and the industry. Making, therefore, a reduction of one fifth in those gross earnings, it appears that half of the adult males of the United States are earning less than $500 a year; that three quarters of them are earning less than $600 annually; that nine tenths are receiving less than $800 a year, while less than ten per cent. receive more than that figure.

Briefly summarized, the available wage data lead to these conclusions for the localities in which the data were collected, and by reference for neighboring localities. The annual earnings (unemployment of 20 per cent. deducted) of adult males employed east of the Rockies and north of the Mason and Dixon Line are distributed over the wage scale thus:

Annual Earnings	Adult Males
Under $200	——
Under $325	1/10
Under $500	1/2
Under $600	3/4
Under $800	9/10

[5] Statistics of Manufacture, 1908, Boston, 1909, p. 82.

[6] Bureau of Statistics, 1909, Camden, 1910, p. 120.

[7] Annual Report Bureau of Labor, 1909, Topeka, 1910, p. 10.

[8] Bureau of Labor Statistics, Wisconsin, 1907–08, Madison, 1909, p. 464.

[9] Report on Strike at Bethlehem Steel Works, C. P. Neill, Washington, 1910, p. 60.

[10] Annual Report Statistics of Railways, 1908–09, pp. 34 and 40.

[11] "Unemployment in the United States," Scott Nearing, Quarterly Publications American Statistical Association, September, 1909, p. 539.

Accepting as accurate the standard of living studies which set the efficiency minimum for a man, wife and three children under fourteen at $750 to $900 per year, it appears that a very large group of American wage earners are unable to support their children on an efficiency basis. If unmarried, their wage is adequate; if married, with a family of more than three children, their wage is insufficient to maintain efficiency. As the average American family is five, many of these earners are probably receiving less than efficiency wages. If this apparent discrepancy between wages and an efficiency standard of living really exists, it should have a reflex in underfed children, in undesirable living conditions, in anemic men and women—that is, in the typical products of low efficiency standards. That such products do exist, the meager data at hand indicate; but the exact character or extent of the low standard condition is most uncertain. John Spargo in a recent book[12] attempting to estimate the number of underfed children in the schools, concludes that there are between 60,000 and 78,000 such in New York City alone. A much more authoritative study is contained in a report of the Chicago School Board, which asserts:

> Five thousand children who attend the schools of Chicago are habitually hungry. . . .
>
> I further report that 10,000 other children in the city—while not such extreme cases as the aforesaid—do not have sufficient nourishing food. . . .
>
> There are several thousand more children under six who are also underfed, and who are too young to attend school.
>
> The question of food is not the only question to be considered. Many children lack shoes and clothing. Many have no beds to sleep in. They cuddle together on hard floors. The majority of the indigent children live in damp, unclean, or overcrowded homes, that lack proper ventilation and sanitation. Here, in the damp, ill-smelling basements, there is only one thing regarded as cheaper than rent—and that is the life of the child.
>
> We find that a large number of children have only bread, saturated in water, for breakfast day after day; that the noon meal is bread or bananas, and an occasional luxury of soup made from pork bones; that children often frequent South Water Street begging for dead fowl in the crates or decayed fruit; that others have been found searching for food in alley garbage boxes, and several cases were reported where hungry children at school picked up crusts of bread or fragments of lunch which other children had thrown away.[13]

Families are not only undernourished—they are badly housed as well. Here, for example, is a description of the housing facilities afforded a group of Pittsburgh steel-mill workers.[14]

> In one apartment a man, his wife, and baby and two boarders slept in one room, and five boarders occupied two beds in an adjoining room. . . . Not one

[12] "Bitter Cry of the Children," John Spargo, New York, Macmillan Co., 1906, Chapter II.

[13] Report of Minutes, Board of Education, City of Chicago, October 2, 1908, pp. 4–5.

[14] "Painters' Row," Elizabeth Crowell, *Charities*, February 6, 1909, pp. 914–915.

house in the entire settlement had any provision for supplying drinking water to its tenants. . . . They went to an old pump in the mill yard—360 steps from the farthest apartment, down seventy-five stairs. This town pump was the sole supply of drinking water within reach of ninety-one households comprising 568 persons. . . . Another row of one-family houses had a curious wooden chute arrangement on the back porches, down which waste water was poured that ran through open drains in the rear yard to the open drain between this row of houses and the next. They carried other things beside waste water—filth of every description was emptied down these chutes, for these six families and three families below on the first floor had no closet accommodations and were living like animals.

Interest may perhaps attach, in this connection, to the menu of one New York family, the children of which were considered by the examining physician to be undernourished.

Sunday.	Breakfast, bread and tea (no milk).
	Dinner, soup (from soup bone) and potatoes; bread.
	Supper, bread and tea (no milk).
Monday.	Breakfast, bread and tea (no milk).
	Dinner, fried potatoes (lard) and gravy (made from left-over soup).
	Supper, bread and tea (condensed milk in tea).
Tuesday.	Breakfast, bread and tea (condensed milk in tea).
	Dinner, boiled rice with tomatoes (canned).
	Supper, bread and tea (condensed milk in tea).
Wednesday.	Breakfast, bread and tea (condensed milk in tea).
	Dinner, boiled potatoes and stewed tomatoes (canned).
	Supper, bread and tea (condensed milk in tea).
Thursday.	Breakfast, bread and tea (no milk).
	Dinner, bread and molasses (mother out working).
	Supper, boiled cabbage.
Friday.	Breakfast, bread and tea (no milk).
	Dinner, boiled cabbage.
	Supper, bread and molasses.
Saturday.	Breakfast, bread and tea (no milk).
	Dinner, boiled potatoes.
	Supper, bread and tea (no milk).

Individual cases, like the preceding, prove nothing, and none of the data relating to the results of low standards will provide an adequate basis for scientific deduction, but it nevertheless points to conditions such as might easily be anticipated when the discrepancy between efficiency standards and wages actually paid is considered.

Is there any way in which this lowered efficiency, due to low wage standards, can be measured? Are there any directions in which it will be felt by the working force, and hence by the employer?

The standard of living facts and the wage facts are indisputable; low standard conditions are appallingly frequent in some districts. What will the end be?

The members of those families which are forced to live on inefficiency standards are subject to a decrease in (1) physical efficiency, (2) intel-

lectual keenness, (3) disease-resisting power, (4) length of life. No employer who desires to maintain the efficiency of his working force, and what employer does not desire to do so, can afford to tolerate for a moment any one of these four conditions.

He can not afford to work with a labor force which is devitalized physically. Even though modern industry does not demand of the majority of operatives great physical strength, it does demand a good physique, since neither work requiring strength, dexterity nor brain power can be carried forward efficiently and enduringly in the absence of physical stamina. "A sound mind in a sound body" is a good old saying, which holds true in a vast majority of cases.

Intellectual keenness and foresight in the wage worker is one of the essential factors in the success of the employer. Workers must be interested in their work; they must work for the firm; they must apply themselves seriously to the tasks in hand. All of these and many other commonly named requirements are impossible to attain in the face of mal-nutrition, bad housing and insanitation.

Sickness is one of the greatest foes of the manager. Hands are "off." They have headaches, colds, and like ailments in endless profusion. Irving Fisher estimates that in the United States 3,000,000 persons are at all times seriously ill; while the "well man" loses four or five days every year from minor ailments, such as colds, headaches and the like.[15] Much of the illness is preventable and would be impossible if men and women were not devitalized by low standards of living.

Employers have perhaps their greatest difficulties in replacing men who drop out of the work because of sickness or death, yet the average length of life in the United States is only half what it might well be. Men born in American cities of native white parents live on the average only 31 years.[15] The length of life in America is astoundingly short, and short because men and women have not the wherewithal to maintain efficiency—a fact which is fully established by the enormously higher death rates among the working classes. When a man or woman drops out of your factory, and you struggle for years to fill his or her place, you are often striving to cure what you might more easily prevent—early death due to low living standards.

Efficiency is an essential item in the success of any business—not the efficiency of any one man, but of the entire working group. Although efficiency is so intimately connected with success, on the one hand, it is no less closely related to standards of living, on the other. The efficiency which leads to success can, therefore, be secured only by maintaining living efficiency through the payment of efficiency wages.

[15] "Modern Social Conditions," W. B. Bailey, New York, The Century Co., 1906, p. 227.

THE INSTINCTIVE ELEMENT IN HUMAN SOCIETY

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FOR two decades or more sociologists have been proclaiming that the development of their science must be through psychology and must wait accordingly upon the development of that science. Now that psychology has achieved a very considerable development and relative unanimity of opinion with regard to certain fundamentals, it is strange to find sociologists, and workers in the social sciences generally, loath to make use of some of its assured results.

Perhaps no single truth in modern psychology is better assured than that the whole mental life of man rests upon certain native reactions or innate impulses which the psychologists term instincts. Instinct has come to be recognized, then, as an all-important factor in the mental life by psychologists; but at the very time that the recognition of the importance of instinct in psychology has become universal certain sociologists are questioning the importance of instinct as a factor in human social life.[1]

This situation is serious enough to demand thoughtful consideration on the part of all interested in the social sciences. For years the social sciences, and especially sociology, have been striving for recognition as positive sciences. Such recognition it would seem can only come when sociology and the other social sciences openly rest their work upon assured results in the now recognized positive sciences. Sociology, indeed, as an intermediate science between the special social sciences and the natural sciences, can not be anything more than a study of the biological and psychological factors in human social life, with reference to certain problems, such as the problems of social organization and social evolution. It is difficult to see what place the sociologist has among the laborers in positive science, unless it is a part of his business at least to formulate the results of biology and psychology so as to throw light upon problems of social organization and social evolution.

Of course, as a matter of fact, students of the social sciences can not escape making continual use of biological and psychological facts and principles in their investigations and discussions. The trouble is that they frequently prefer to study out these facts and principles for themselves rather than make use of the consensus of opinion among the

[1] See, *e. g.*, the *American Journal of Sociology*, Vol. XV., p. 616. Cf. also the *Political Science Quarterly*, Vol. XXV., p. 514.

best authorities in biology and psychology. Very often the biology and psychology which they use is comparatively crude, and from ten to twenty-five years behind the times. It is, of course, entirely commendable on the part of the workers in the social sciences that they should not be over hasty in accepting any theory in biology and psychology. But when these theories have been tested and generally accepted, then the burden of giving adequate reasons must rest upon the sociologist who rejects such theories. Such is the case with the theory of instinct in psychology.

Aside from the misunderstandings concerning the psychological use of the conception of instinct, there are certain objections of a definite nature which students of society have made to the employment of the conception in sociology and in the other social sciences. These objections may be classified under three heads.

1. It is said that man has few or no instincts, but that he acquires practically all of his characteristics by imitative absorption from his social environment. This, however, is in direct opposition to all the results of modern scientific psychology. It is now over twenty years since Professor James upset the older view of human nature by saying that man had more instincts than any other animal. This view, after years of controversy, has finally won out in psychology and is now not seriously disputed by any one who understands what the psychologist means by instinct. Thorndike states that the list of human instincts is ever increasing because many actions which have commonly been credited to the acquisition of individual experience are coming now to be known as really the gifts of nature. He says,[2] "the more carefully mental development is investigated, the more we find human life everywhere rooted in instincts."

2. The second objection which certain students of society make to the use of the conception of instinct in sociology is that instincts, while they may exist, are in no degree determining factors in human society, but are simply rudimentary impulses whose expression is wholly determined by the social environment (chiefly economic conditions). This objection is based partly on misconceptions of instinct, partly on a faulty psychology which over-emphasizes the rôle of stimulus in initiating conduct. The full answer to this objection will be evident from what is said later.

3. The third objection which some make to the use of the concept of instinct in sociology is that instinct is but a term, a concept, and that it stands for no real phenomena; in short, that "instinct" is merely a metaphysical concept, not a reality. This objection is based upon an inadequate appreciation of the positive and biological character of modern psychology.

We shall try to show that all of these objections to the use of the

[2] "Elements of Psychology," p. 190.

psychological conception of instinct in sociology are invalid and that, if one is to study human society psychologically, one must begin with the native elements found in the individuals which compose that society, that is, with the instincts, and then show the part which they play in social organization.

A subconscious objection in the minds of many students to the use of the conception of instinct in the social sciences is doubtless the wrong use to which the conception has been put in the past. Ever since Aristotle, instinct has been a sort of a "catch-all" into which were thrown all the problems that were in any way baffling. We have had theories of social organization which traced practically everything in human society to a supposed "social instinct" in man. It has been claimed that individuals entered into social relations through this instinct or through that. The state has been explained through a specific political instinct in man; religion has been explained through a religious instinct in man; economic phenomena have been traced to the workings of a specific economic instinct, and so on. No doubt this older way of explaining man's social life through various specific instincts was unscientific and the reaction against such crude methods is fully justified. Even Aristotle's instinctive theory of society, as developed, at least, by some of his followers, is open to severe criticism because, as we shall show, man enters into social relations, not through any one or even a few, but through practically all of his instincts.

Crude recognition of the instinctive element by recent thinkers along social lines has not helped matters. The "properties of human nature," such as the aversion to labor, the love of gain and the like, which the earlier and some of the later economists have made use of, are undoubtedly very far from scientific conceptions. So also the use which certain sociologists have made of the term "unconscious," by which they seem to mean very largely the instinctive. Again the use of such a vague term as "desires," to which Ward traces all social occurrences, is open to the same objection; for some sociologists use the expression "the desires," meaning the native impulses; others mean by it the feelings.

Illustrations of vague and unscientific uses of psychological terms and conceptions in the social sciences might be multiplied indefinitely. The few that have been pointed out are, however, perhaps sufficient to emphasize that all such vague and crude uses of psychological concepts must be replaced in the social sciences by usage which is in accord with the best development in modern scientific psychology. When this is done with the conception of instinct it will be found to accord entirely with the requirements of positive science, and to be especially in harmony with the soundest biological views of life.

Misunderstandings, then, of the psychological usage of the term instinct and the resulting misconceptions of what instinct really is, are

largely at the bottom of the denial of any rôle whatsoever to the instincts in human social life. Drawing their conceptions of instinct from a crude animal psychology, many social thinkers seem to conceive of instinct as something hard and fast, as a definite, "crystallized" mode of activity, such as we find, to be sure, in the lower reaches of animal life, especially among the insects. Such thinkers conceive, accordingly, instinct as having something fatalistic and inevitable about it. But practically all psychologists are now united in repudiating such a conception of instinct. The instincts of all the higher animals, man included, are not of this hard and fast and definite type, but are modifiable through training and experience in many ways, even though they are influential in determining animal behavior. Let us see then what conception of instinct modern psychology has worked out. In man, as in all the higher animals, there is a highly developed nervous system, with multitudes of connections between its elements. These connections are pathways of nervous currents. Many of these connections are inborn and seem to be as much a part of the heredity of the individual and the race as stature, the color of eyes and hair, or any other physical characteristic. Hence the nervous system is characterized by a multitude of more or less perfectly developed preorganized reactions which are a part of the individual's heredity. These preorganized reactions have been established through the operation of selection, biologists tell us, upon variations in the hereditary elements, in the same way in which the bodily characteristics of the species have been established. In all the higher animals, and especially in man, on account of the complexity of his nervous system, these native reactions are not fixed and unalterable, but are subject in a large degree to modification or elimination according to changes in the environment. Nor are they always specific but they are often, as Thorndike says, indefinite and general.[3]

Instincts are then inborn pathways of nervous currents, which have as their functional correlate inborn motor tendencies, and as their psychical correlate inborn psycho-physical dispositions. They are evidently the psychological aspect of racial heredity, and it is as inconceivable that the organic individual should exist without them as without the equipment or general bodily structure itself. As instincts are not acquired by the individual, but are given in the germ, they are transmitted from generation to generation, varying only as other biological characteristics of the stock also vary. Inasmuch as they are characteristics of the highest and most unstable portion of the organism, the nervous system, they probably vary more widely than the grosser physical traits. They are more modifiable and alterable, owing to the fact that only about one third of the connections in the nervous system are made at birth, the other two thirds being acquired by the individual

[3] *Op. cit.*, pp. 189–190.

during his life time. These acquired connections must, of course, very greatly modify the character of the original connections, even though they are made upon the basis of the original connections. There are in man therefore no definite, hard and fast instincts such as characterize the lower types of animals, but rather a complex series of more or less generalized instinctive reactions.

It is evident that the modern psychological concept of instinct, so far from being metaphysical, is wholly biological. The concept of instinct as inborn pathways of nervous currents is the necessary correlate of the biological doctrines of selection and heredity. While the nervous system is more largely modifiable by use than any other part of man's organism, yet its essential structure is inherited and belongs to the stock or the phylum rather than to the individual. The native reactions which are inherited in the hereditary structure of the nervous system are the necessary original equipment with which the individual starts his struggle for existence. Some of these reactions are so simple in organization that they do not enter to any extent into consciousness, and these are known as reflexes. These need not concern us, since they enter directly only into the physical life of the individual organism. But the great majority of these native reactions are complex motor tendencies and have conscious accompaniments, especially feelings, emotions and "desires." Moreover, the acquired habits of the individual, psychologists tell us, are wholly built up through modification of these native reactions. When the instinctive reaction fails to function properly consciousness comes in to adapt the organism to the new situation, the adaptation being made chiefly through the selection from the varied native impulses. All of the habits of the individual therefore rest in the last analysis upon the native impulses. Now, the thesis of this paper is that if instincts are the starting point for man's mental life, they must be for his social life also; if, upon the instincts of the individual, all habits are built, so likewise upon them all social customs, institutions and organization must ultimately rest.

It should be noted that according to the modern psychological concept of instinct, instinctive reactions will vary in different individuals and races. Inasmuch as instinct represents the preformed pathways in the nervous system, made in response to demands of previous life conditions,[4] that is, created by selection, we should not expect to find exactly the same instinctive reactions in the different races of man. Their instinctive reactions, while fundamentally the same, will vary in some degree because the different racial stocks have been exposed to different selective agencies. This explains why race is a factor in social organization and evolution. Again, the two sexes have been created by somewhat different selective and developmental processes; therefore,

[4] "Response" and "demand" are of course used figuratively, without teleological significance.

their instinctive reactions to the same stimuli may often vary considerably. It is in this degree that sex enters as a modifying factor into all forms of association. Just as biological variation constantly alters the physical aspects of heredity, so it also constantly alters the inborn psycho-physical dispositions of individuals. The concept of instinct, therefore, leaves as large a place as any sociologist could desire for the influence of selection, of race, of sex and of inborn individual differences in the social life.

While there can be no question but that instinctive reactions, from the psychological point of view, are the basis of the relationships of individuals in society, nevertheless, it is very difficult to say just what proportion of human activities may be regarded as primarily instinctive. It is especially difficult to trace the instinctive element in human institutions as they exist in modern civilized society. It is certainly incorrect to explain anything important in the social life of civilized peoples simply through instinct, on account of the fact that instinctive reactions under such conditions are overlaid with a mass of habits which we term custom and tradition, and are constantly modified or inhibited by many other social factors. On the other hand, it is an equally serious error to ignore the instinctive element, even in the complex conditions of modern life. Even though we can not determine quantitatively the relations between the instinctive and acquired elements in any given social situation, it is important to note that they both exist and that the instinctive is the basis of the acquired. Some tests of the instinctive element in human society can, however, be devised by psychologists and sociologists. In general we may safely regard those activities as instinctive which characterize the species, that is, which are relatively common to all men in all stages of culture. Again, those activities which man shares with the animals below him may, for the most part, be regarded as instinctive. Finally, from the study of the child and the adolescent, the sociologist may also perceive with more or less clearness some of the instinctive elements in human conduct and character.

Another difficulty which confronts the sociologist in tracing concretely the instinctive element in any given social situation is the great complexity of human instincts themselves. It is, of course, a grave psychological error to suppose that there are a number of separate and distinct human instincts which exist side by side without running into each other and which have each a separate function to perform. Rather human instincts, corresponding to the conception of them just given as inborn pathways in the nervous system, continually run into each other and reenforce each other like a network of streams or electric currents. The consequence is that human institutions are generally expressions of a number of instincts combined in various ways, besides being, of course, often built up largely on the basis of acquired traits. It is

only in the simpler forms of association, perhaps, that we can trace most clearly the instinctive element, although all human institutions must ultimately rest upon human instincts, for the instincts are instrumental not only in furnishing the primary or original activities, but also in furnishing those "sanctions" which are the peculiar mark of those forms of association which we term institutions, since the "feelings" are more largely attached to the native reactions than to acquired habits.

It is in the simpler forms of human association, then, that we may see most conspicuously the workings of instinct. The family especially shows most clearly the influence of instinctive elements, and here it may be remarked that the family must be regarded as in many ways the most typical of all the forms of human association, illustrating in the clearest manner possible the simpler biological and psychological factors at work in human social life generally. The family as an institution evidently rests upon two great primary instincts, the sexual instinct and the parental instinct. Like all instincts, these are varyingly developed in different individuals. Sex attraction has always been recognized as the basis of human family life, and as one of the great primary forces in human society, but the influence of the parental instinct has not been so generally recognized. Careful study of human society shows, however, that it is the parental instinct which gives stability to the family, and so is the real foundation of that institution, as we understand it, in all ages and among all peoples. This is strikingly shown by the fact that, among both civilized and uncivilized peoples, childless couples separate much more readily than those that have children. It is also shown by the customs and laws of practically all peoples. The instinctive reactions of the sexes and of parents and children, then, give rise to a whole series of social coordinations which express themselves variously in the institution of the family; but this is not denying, of course, that the institution of the family, as we know it, is largely also a product of custom and tradition. To see the simple instinctive form of the family we must turn to such peoples as the Andaman Islanders, the Bushmen, the Fuegians and other primitive peoples who live a purely animal existence. In such peoples we find the simple, pairing, monogamous family group of a more or less unstable character which is practically the same as the family group which we find among the higher apes and many other animals. We are warranted, therefore, in concluding that such a form of association is not only unreflective, but also almost entirely a product of instinctive reactions.

Many of the other simpler forms of human association illustrate equally well the workings of the instinctive element. Thus the forms of play among children and the "struggle groups" of adults give very clear evidence of relatively unmodified instinctive reactions. While the social life of adults, as has already been said, is very far removed from

the instinctive plane, yet evidences of the workings of purely instinctive elements are to be found, not only in the various forms of social conflict, but also in the forms of social attraction and of cooperation. While there is no single "social instinct" which can be invoked to explain the forms of man's social life, there is a whole series of reactions connected with instinctive forms of sociability, beginning with the parental instinct. That sociability is itself an instinctive, not an acquired, trait has been amply demonstrated by the researches of practically all modern sociologists. Professor Giddings especially has shown the instinctive attraction which exists between individuals of like physical and mental traits; and that such instinctive sociability, along with the acquired traits built immediately upon it, accounts for much in our social life. More recently Mr. Trotter, a British sociologist, has shown very conclusively the obscure reactions of the same instinctive sociability in practically all phases of man's social life.[5] Illustrations of this sort might be indefinitely multiplied, but it is not necessary to do so, because all this is what any thinker would expect who takes the biological view of life. While the sociologist is not yet ready to trace in any final way the workings of various instinctive reactions in human society, there can be no doubt that such a task is scientifically feasible, and will doubtless be accomplished in the near future.

All of this, of course, in no wise denies either the influence of intellect or of objective conditions upon social evolution. As the writer has elsewhere emphasized,[6] it is the intellectual elements in human social life which after all give it its distinctive character in contrast to the social life which we find among animals. It should be remarked, however, that these intellectual elements quite as often work in line with instinctive impulses as in the way of modifying them. Again, the influence of objective conditions is, of course, to be taken for granted in considering human society from the standpoint of instinct, since no instinctive reaction can develop unless the objective environment furnishes the appropriate stimulus. It is a mistake, however, to consider that such stimuli in the objective environment of themselves give rise to the activity; for nothing is more clearly demonstrated in the psychology of the present than that the organism frequently, indeed usually, seeks the stimulus. The stimulus is not that which causes action, but is rather the opportunity for action, the organism being self-active; hence the error of those who would interpret social life and movements entirely in terms of objective conditions. The "economic determinists," for example, are under the burden of showing that all the psychological and biological factors in human nature are mediated

[5] See his article on "Herd Instinct" in the *Sociological Review* for July, 1908.

[6] See article on "The Origin of Society" in the *American Journal of Sociology*, Vol. XV., November, 1909.

and controlled in their expression by economic conditions. The mere fact that man's social life shows many traits in common with the social life of animals, among which there are, strictly speaking, no economic conditions, is in itself fairly good evidence that the native impulses are by no means wholly controlled in their expression by economic conditions, or any other single set of causes, but that they are in themselves, given the spontaneity of human nature, a determining factor in many, if not in all, social situations.

The theoretical consequences of the recognition of instinct as a subjective social factor are certainly not to be feared. On the contrary, the recognition of instinct as a factor would greatly broaden and deepen sociology and all of the other social sciences, and would bring the psychological aspect of those sciences into harmony with their biological aspects and with the biological sciences generally. The social sciences have suffered unduly from intellectualistic views of human nature and human society. As long as psychology was intellectualistic, it was unavoidable that such a significant human relation as mother and child, for example, should be explained in terms which now seem to us trivial as well as superficial. As we grasp the biological view of life and see clearly that all life is continuous, and that relations involved in human association are the outcome of forces that have been working upon life for myriads of years, and are therefore freighted with meanings far beyond the individual life, we shall avoid trivial and superficial explanations of things human. We shall see at once, for example, that such a relation as mother and child can be explained only in terms of instincts which have been created by age-long processes, and not in terms of a superficial, intellectual pity of the mother for the helplessness of her child. It should be manifest, therefore, that the concept of instinct in the social sciences will give to those sciences a vital relation to life generally. Deduction from biological and psychological facts, if carried out with proper scientific safeguards, is not to be feared in the social sciences; for it is only by accepting the results of the other positive sciences, and especially of the biological sciences, that sociology can itself hope to become a positive science.

It is only necessary to say a word in conclusion regarding the practical consequences of the recognition of the large rôle of instinct in human social life. Scientific educators have recognized now for over a decade the part which instinct plays in individual activities and development, and scientific education has made the instinctive element the basis for the scientific training of the individual. It is, perhaps, too early to judge finally the results of this movement in education, but thus far they appear to be wholly beneficent, and we are apparently approaching scientific methods in the control of individual development. The case is apparently not different in social development.

The recognition of the true rôle of instinct in human social life will serve at once as a basis for scientific social work and as a means of transcending the purely instinctive plane of social activity. It would seem, therefore, that the practical consequence of the recognition of the importance of the instinctive element in human social life would be to establish a wise conservatism with reference to the reconstruction of institutions and at the same time a progressive radicalism as regards the ultimate amelioration of social conditions. Any plan of social reorganization which is made without regard to man's instincts is probably destined to meet with as great failure as any plan of individual education which is made without regard to native impulses and capacities. On the other hand, human instincts are indefinitely modifiable, through selection in the race and through education in the individual. There is nothing in them, therefore, which can put any permanent obstacle in the way of carrying out any rational measure of social reform, although the recognition of instinct as at the basis of human social life, points to the conclusion that the only sure and probably the only safe method of social reconstruction is through education. When the instinctive element is thoroughly understood it certainly can be controlled, and in this sense transcended.

As we have seen, man's instincts were created by the selective influence of past living conditions. It is hardly probable that civilization has as yet very greatly altered the instincts of civilized man from those of the barbarian and the savage. Those persons who, like Fourier, claim that the instincts and the correlated emotions should be the supreme guide in social life would plunge society again into barbarism. Our instincts, as Professor Thorndike remarks, would be a much better guide if we were still living a wild life in the woods than they are in our complex civilized society. It is the dominance of instinctive control and of instinctive activities in existing society, rather than of rational control and rational activities, in other words, which creates many of the problems of our present civilization. As Sir Francis Galton has pointed out, many of these problems are due to the fact that man's instincts are not yet adjusted to the new and complex social conditions in which he finds himself. It is idle to think that it is practical to secure such adjustment through the elimination of socially undesirable natural tendencies by any means of artificial selection. That is too far in the future to be worthy of serious discussion. The only means which remains, therefore, of adjusting man to the requirements of a complex social life is to modify and control instinctive activities by a system of scientific education of the young, that is, by a system of social character building. The great problem of civilized society, therefore, is not to suppress man's instincts, for that can not be done, but to guide and control them by a system of scientific education, so that they will discharge themselves only in paths of social advantage.

TYPES OF MEN

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THE study of human types has fallen into disrepute because of the advance of exact science. Accurate measurements have displaced crude observations. In this way, the science of eugenics has been evolved with many earnest advocates who think the victories of physical science may be duplicated in social fields. Between this group and the workers in the various fields of social betterment there is a chasm and much friction. This is partly a matter of temperament, but it is largely due to the different methods of research which the two groups employ. The relation between the social worker and those he would help is personal, and his judgment of them is based on observation. His creed demands a saving of life; hence we find him engaged in the struggle to prolong life and to prevent the elimination the eugenist favors. Social elimination, he would say, is so crude a process that it sweeps off a thousand deserving persons (especially children) to the one really deserving victim of its processes.

The eugenist has an advantage in his acceptance of the doctrine of the non-inheritance of acquired characters. A direct connection is assumed between the visible trait to be favored or eliminated and the characters of the germ cell that are passed on from generation to generation. If the character make the visible trait, rigid selection based on the elimination of traits is the only way of ridding the race of undesirable traits. Improving the condition of individuals would help them, but if traits do not influence characters, such betterments would have no effect on coming generations. The social worker, however, thinks that his efforts to help individuals are of social importance, and hence sympathizes with, and suffers from the downfall of Lamarckianism. The statistical averages of the eugenist also seem to complement the work of biologists by giving an objective measure of innate characters. Biologists can not trace the determinants of the germ cell through the subsequent development of an organism. They are, however, of the opinion that the visible traits shown at maturity are the result of the action of the determinants of the germ cell. To assume that the average development shown at maturity is the index of the germ cell determinants is a natural way of completing this proof.

These facts give to the eugenists the strength they have and make their arguments seem plausible. In a recent article,[1] I have tried to point out the fallacy of their position and to put in more favorable light

[1] The Popular Science Monthly, October, 1911.

the opinion that crude elimination does not improve social conditions. I emphasized the contrast between the unit characters of the germ cell and the visible traits observed in men at maturity. If mental and moral traits are predetermined through innate influences, the visible traits of men can not be altered without corresponding changes in the germ cell. There must also be as many individual determinants in the germ cell as there are observable traits in men at maturity. In contrast to this view, I sought to show that single characters might produce a multitude of visible effects, and that the great mass of social and mental traits could be accounted for without assuming a change in many innate characters.

Most visible traits are modifications in individuals, and not variations in germ cells. Modifications are acquired characters due to the action of the environment, social and physical, which would not appear in children if the environment were radically altered. Chastity, thrift or temperance might readily be transformed into their opposites with no other changes than the environment imposes. These traits reappear for many generations in certain families, and seem to be inborn, but we have only to make a radical change of environment to see them displaced by their opposites. Civilization and culture perpetuate themselves through the permanence of social and economic conditions. Degeneration sets in with any slump of the forces that compel a constant repetition in each generation of the acts and thoughts of their immediate ancestors.

The eugenist concept of biologic development is that of a multitude of individual characters each of which becomes visible in specific external traits. Germ-cell changes are presupposed with each change in the statistical averages obtained by the measurement of individual parts or organs. If this be true, statistical evidence based on the measurements of individual traits is proof of the presence of a corresponding character in the germ cell, and any variation in the one is evidence of a change in the other. The opposing view assumes that the visible traits usually are modifications due to the action of the environment which are not inherited, but must be reimposed by the action of external conditions on succeeding generations. Modifications of this kind do not come singly but in groups. A change of climate or of the food supply is not to be measured by a single change, but by many minor changes that alter all parts of the body. A clear upland climate will give greater vigor. This will result in greater activity through which many structures are altered. These will be followed by changes in habits and customs, creating new traits or changing the relative prominence of old ones. And finally social and political changes occur accompanied by moral and religious modifications. In these ways a complicated network of changes arise that are to be referred to ultimate changes in climate, food, health and activity. These causes create types differing

in a thousand ways, physical and social. Types are easy to recognize, but hard to measure. We use many uncertain characteristics to distinguish them, and yet must expect that any one of them will fail if it is put to a definite test.

Some changes, however, are true variations due to the evolution of germ cells. To get at these, different reasoning must be used, but the outcome is the same. As a starting point I shall take a contrast employed by the late Dr. John Ryder, of the University of Pennsylvania. He was fond of asking his students whether the hard parts of the body determined the soft parts or whether the reverse is true, thus making the soft parts determine the hard parts. The ordinary assumption is that bony structures are manifestations of the germ cell determinants. This gives the static measurements on which statistics are based, and from which the ordinary view of heredity is derived. Dr. Ryder's view was the opposite of this. He held that the bony structures were the consequence of the activity of the soft parts and were laid down later. Those parts became solid and unyielding in which the metabolism was defective. The solid ingredients of the blood were deposited there; bony structures thus came into being and seemed a part of heredity, when in reality they were a consequence and not a cause.

This view has not won general acceptance. There is, however, enough truth in it to make certain that these are dynamic characters, which must be measured not in terms of structure, but in bodily activity and its effects. An illustration of this is the contrast between anabolism and katabolism, as is also the increased plasticity manifested in the prolongation of childhood. Plastic brain cells do not result in a single mental trait, but in a change in the whole range of mental activity. The races of slow maturity differ from those rapidly maturing in many traits, and yet they may all be the result of a single variation involving the increased plasticity of brain cells. Among the psychic characters fear is an example of this kind. Cowardice, deceit, falsehood, humility and other traits are clearly the outcome of one fundamental variation. The supplanting of fear by courage would transform a whole civilization, and modify its best known characteristics. Dynamic variations are thus like environmental modifications. Groups of traits change or appear together, due to one primary cause, innate or external. Types are thus formed that differ in a thousand ways and yet are readily referred back to a few ultimate causes.

If types are formed in this way, single visible traits can not be altered unless a change is made in other traits that are due to the same cause. The changes from upland to lowland, from cold to hot climate, from damp to dry regions, or from meager to abundant food modifies many external traits at the same time. Races of men are formed by each external change which continues long enough to compel an adjustment to it. Each single visible trait does not have an independent

cause. If liquor drinking is correlated with greater physical vigor in men, an elimination of drinkers is also an elimination of vigor, and would result in race deterioration. Social causes are simpler and deeper seated than are social effects. A study of the types of men and of the relation between the various groups of visible traits must therefore precede attempts to modify races by the elimination of single traits.

Prominent differences in men arise from the contrasting effects of upland and lowland climates. An upland race, if in a dry region, has a purer and more bracing atmosphere, and hence does not need so much lung power. It must develop greater vigor and endurance, partly because of the cold and partly because of the game it chases and the cattle it herds. Its food is drier, harder and more condensed; hence a better development of the jaw and its muscles results; along with this come smaller stomachs, better digestion and fresher blood. A tall, narrow-chested man comes into being, who is in marked contrast with the short broad man of the lowland regions. These typical differences are accompanied by minor traits, not always found in all of a given race, but often enough to indicate that they have the same general causes. Long heads and round heads represent dynamic changes, even if we can not trace them back to given climatic origins. Some races and persons have a marked development of the lower face with prominent jaws and strong facial muscles. These people like hard foods, enjoy chewing their food, and, if possible, keep something in their mouth, gum or tobacco or the like, to exercise their jaws. Baseball players are noted examples of this habit; it indicates a surplus of energy and strong muscular development. It is equally plain that those with a weak lower jaw and muscles take readily to soft sweet foods, that they suck or gulp down rather than chew. This means a better muscular development of the throat. A snake, for example, sucks down its food, while a tiger chews his. In men the sweets and the meats are causes that bring out this difference between the chewers and suckers. Another like contrast is between the mouth breathers and the nose breathers. We speak of breathing as a habit, and yet different habits would not tend to be formed if muscular differences did not exist. Each activity is the outlet of energy, which tends to express itself through bodily mechanisms. The strong grows at the expense of the weak; each difference in bodily powers tends to develop a type.

These contrasted traits are valuable, not so much for the definiteness of their manifestation as for the general conclusion their study warrants. The two types of men differ somewhat in their dynamic characters, but more in the environmental modifications which climate, food and occupation have created. The upland types are tall, bony, narrow-chested with well developed lower faces. They breathe through the nose and eat hard foods. The lowland types are short, thick set, live on soft foods, and use large quantities of coarse or liquid foods.

They have a poorly developed lower face, and breathe through the mouth. The lowland races are doubtless the older type and represent the primitive characteristics of men. At some point an isolation occurred, possibly with the pushing up of the great plateau of Central Asia and the formation of dry desert uplands. An oasis or an isolated upland valley would combine, both in food and climate, the elements on which the formation of the more vigorous type depended. Later comes the renewal contact with the lowland races and the descent of the northern nomad to the fertile lowlands as a conqueror. From this union come the mixed races that occupy the medium altitudes. The upland races can not go too far down south without facing extinction, while the lowland races have been unsuccessful in facing the rigor of dry, cold uplands.

I shall call the pure uplander the long-faced type, the pure lowlander the round-faced type, and the mixture of the two, the oval-faced type. I use this contrast not because it is the only one that might be selected, but because it permits of a threefold division more readily then the others. An additional reason is that the round-faced and the long-faced women are now popular contrasts. The frontispieces of magazines give us the round-faced girl as the approved type of female beauty, while the suffragette, the old maid, the intellectual woman and the freak are pictured with long faces and protruding jaws. The difference, however, is not merely in the skull and the bony structures of the face. Even more marked is the contrast between the placid plumpness of the round face and the nervous make-up of the long face. Like differences are observed in man, and they give a ready means by which the two types can be distinguished.

In the application of current biologic theories to the human race, we must face the fact that there are two points or centers of elimination. As the race moves down or into hot countries, the upland type or the mixed type in which it is dominant is eliminated, while an upward movement, or one into cold dry regions tends to weed out the lowland type and the elements that it has given to mixed breeds. Changes in food and drink create a like and, at the present time, a more prominent tendency in these directions. Diseases also contribute their share towards this double elimination. Some, like tuberculosis, work against the upland type, while the fevers and alcohol weed out the lowlanders. The action of this double elimination can be shown by using the Mendelian law of crosses. When parents of mixed breeds unite, the children are one fourth pure of each pure type and one half of the mixed type. If none of the pure types survived, the next generation, being children of the mixed type, would again be one fourth of each of the pure types and one half of the mixed type. In each generation the pure breeds might be eliminated, and yet one fourth of the children of mixed parentage would be representatives of each pure type. Elimination

could not wipe out a type under these conditions. The unit characters on which elimination acts are plainly in the pure races, which are constantly eliminated, but constantly reappear in the descendents of the mixed types.

That this is not mere theory, but an actual condition, is shown by the way elimination is now working among the civilized races. The long-faced woman is narrow hipped and large boned. Child-bearing to her is difficult and many, therefore, do not marry. Men dislike the long-faced woman and seldom marry her unless forced by economic necessity. The result is that an elimination works against long-faced women. They become the old maids and business women, or, if married, are the source of the much-discussed race suicide. The long-faced woman disappears in these ways in each generation, to reappear in the next as the pure element in the mixed or oval-faced marriages. We can, thus, have a perpetual succession of long-faced women, even if they have no children. The round-faced woman, on the other hand, is broad-hipped and makes flesh rather than bone. Men prefer her to her long-faced sister. She gets married early and bears many children. The tendency, therefore, is to perpetuate the short, thick-set women of the type that men admire.

Among men, however, the opposite tendency prevails. The tall, nervous, long-faced man has more mental vigor and moral control. The round-faced man lacks initiative, is governed by tradition, and readily accepts the subordination, exploitation and poverty that come with defeat. He suffers more from epidemic diseases and is a ready victim of dissipation. In civilized countries his lack of earning power forces him into the slums of cities, or into the less favored occupations in the country. In these ways, he is forced into places and positions where the death rate is high. Against him, an elimination is working that cuts him off in each generation almost as fully as elimination works against the long-faced women. We thus have effective processes that weed out the round-faced man and the long-faced woman. This means that the productive unions are between the long-faced and oval-faced men on the one hand, and the oval-faced and round-faced women on the other. So long as the long-faced man is more productive, and the round-faced woman more fertile, the marriage of the two will create the mixed race found in northern countries. It is only in southern regions that the pure round-faced type prevails in both men and women.

Elimination thus leads not to extermination of existing types, but to their perpetuation. If conscious elimination is to be put in operation, it must be made to act on men and women alike. This is extremely difficult, as we admire traits in women we despise in men, and we keep them in existence by this means. We do not, for example, like a deceitful man, but men condone or admire deceit in women. The round-faced woman reproduces her lower morality in the next genera-

tion, and elements of it get into men even if, as a masculine trait, we try to suppress it. If drunkenness eliminated all the round-faced men it would not make the race immune. Alcohol does not, to any extent, eliminate women, and the round-faced type married to long-faced men would continue to breed round-faced men. We could thus have one fourth of the men of each generation die from alcohol, and still have no immunity arise to protect the race.

In contrast to this, a disease like tuberculosis mainly affects the long-faced type. Instead of letting elimination operate against them, it would seem more fitting to put them in upland regions and dry climates where they would not suffer from this disease. Better housing, food, clothing, recreation or amusements may guard against an inherited defect and give a useful life to those who, a generation ago, would have been exterminated by disease. The humanitarian and philanthropist may have been wrong in their remedies, but every discovery in science or medicine proves the soundness of their general view and puts them into a position to be of aid to the uplift of mankind. We can not, as yet, spare either the long-faced or the round-faced types. While this is true, elimination that acts on types and not on single traits must be a bungling means of social progress hurting more than it helps. When men are relocated, eat what they should and live as hygiene demands, our social traits can be reconstructed to meet the demands of a higher civilization. Disease, poverty, vice and inequality can be eliminated. Why leave the tried paths of progress for methods that might work among tigers and wolves, but which humanity has outgrown?

The gist of my argument may be put in a single question. Are we to eliminate men because of the lack of single traits, or should social elimination be the weeding out of bad types? Let me illustrate by a bit of personal experience. I recently went to an oculist, who found that I could read letters so distant that he had to use an opera glass to find that I was right. On the other hand, I had bad muscular adjustment. I combined the best eyesight with the worst muscular adjustment that in each case his practise had yielded. I would, therefore, ask, am I to be eliminated because of bad muscular adjustment, or perpetuated because of my good eyesight? Is, also, Carlyle to be eliminated because he suffers from "eye strain," or to be preserved because of his literary expression? Is John Stuart Mill to be eliminated because of tubercular tendencies, or encouraged because of his logical powers? My answer to these questions is that single defects should be remedied by action on the individual even if this remedy, say eye-glasses, must be applied to succeeding generations. It is only where we have a combination of many inherited characters in one family or group, thus forming an undesirable type, that elimination becomes a necessity. Every innate character is good; it becomes bad only in undesirable combinations or unfavorable situations.

TIME AND SPACE

By CHARLES W. SUPER
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IT requires but a moment's reflection on the part of any one in the least familiar with modern affairs to realize that the time element has come to be the most important factor in business. Railroad trains and steam vessels are run according to time schedules. Offices are opened and closed at certain hours. Employees of all classes are required to report for duty according to the clock, and their task is not completed until they have put in a fixed number of hours. New devices are constantly being placed on the market the purpose of which is to "save time," as the phrase goes. The importance that our day attaches to time is strikingly shown by the fact that for a decade Switzerland has manufactured from six to eight millions of clocks and watches annually; yet this is but a small part of the world's output. It is safe to say that on the average every adult in the United States and in the most civilized countries of Europe is the possessor of a time-piece of some sort. Time may be conceived under two aspects: it may mean a continuous current of duration flowing past a point which we call the present; or it may signify some fixed point or points in that current and the period between them. Remote time either in the past or in the future is usually designated by the term eternity. Any one who reflects soon comes to realize that he can form no concept of duration without beginning or end because it lies out of the range of experience and observation. The popular use of the word time refers exclusively to shorter and longer divisions or units within endless duration, as when we say: "I have not time to talk of this now"; "that never happened in my time"; "the train is on time." The same statement may be made of space. Although it extends in every direction to inconceivable distances, in practical affairs only that part of it is important which can be measured. What is generally called "nature" furnishes us with no accurate standard of measurement of either time or space. For the former the rotation of the earth on its axis gives us an almost uniform period which from time immemorial has been divided into twenty-four hours. No one has ever been able to explain why this number was chosen rather than some other, but it is wholly artificial. Not only this period, but its smaller units, had to be marked by some technical means. For this purpose water-clocks were invented in a remote period of antiquity. The oldest of which any information has been transmitted to us were in use in Egypt as early as 300 B.C. They consisted of a

wooden frame in which was fastened a perpendicular cylinder closed at the bottom and open at the top. In it was placed a piston and rod, and on the rod a number of cogs. These cogs were geared into the cogs of a pulley. At the end of the axle on which the pulley was fastened was a hand behind which was attached the dial-plate to a wooden frame. On the dial, each numeral from I. to XII. was marked twice, and the hand moved round the whole face once in twenty-four hours. The contrivance was set in motion by starting a flow of water from a tank into the space between the bottom of the cylinder and the piston. As the piston-rod rose it turned the pulley and the shaft, and of course with it the hand at the end. By regulating the pressure of the water in the tank, the hand could be made to move faster or slower when it was desired to lengthen or shorten the hours to conform to the relative proportion of daylight and darkness in the twenty-four. Water-clocks were formerly much in vogue in the east and were sometimes very artistically constructed. Haroun al Raschid presented one to Charlemagne that was provided with a striking mechanism and adorned with movable figures such as are now quite common. The ancient Greek designations for the time of both the day and of the night were very vague: "the full market," "candle-lighting," "the first sleep," and so on. Herodotus says the troops that were dispatched by Xerxes to get in the rear of Leonidas left the camp "about the time of the lighting of the candles." It would have been more rational to say "about dark," but he evidently used the common phraseology. Cock-crowing was accepted as an indication of time. A well-known example is given in the story of Christ's trial. It is still much relied on by the peasants in some parts of Europe. In the nature of the case the Greek designations did not indicate the same actual time at all seasons of the year, as candle-lighting would be much earlier in the winter than in the summer. Soldiers divided the night into five watches, the length of which also varied with the seasons. It is not probable that they were accurately measured. This division of time is doubtless the oldest; it is several times referred to in the old testament. Sun-dials were a good deal used by the ancients. The Greeks seem to have received them from the Babylonians. Only the astronomers regarded the hours as of equal length. So far as can be known they depended upon water-clocks. But they were of much simpler construction than the one described above, usually consisting merely of two vessels each of which had a small orifice in or near the bottom. One of these vessels was placed above the other and the water which had been poured into it allowed to trickle slowly into the one underneath. When the lower vessel was full the orifice in the upper was closed, that in the lower opened and placed uppermost, when the same process would be repeated. The speakers in the assembly were timed by these clepsydræ, as they were called; they

are several times referred to in extant orations. While they could be used at any time of the day or night, they required constant attention, and were by no means accurate. Generally the sun and the stars were depended on when they could be seen; for in the climate of Greece and the adjoining lands there are fewer cloudy days and nights than in the more northerly regions. In modern Athens about one half the days of the year are entirely cloudless, and only thirty are noted as cloudy. The Greeks used daylight almost entirely for business and rose very early. A decree of Solon is often referred to which forbids teachers to open school before daylight. For longer divisions of time the Greeks, like most of the people of antiquity, depended on the moon, but they never got the lunar months to correspond exactly with the facts. They reckoned the month at twenty-nine and a half days, or one twenty-nine, the next thirty. Their months, however, were not divided like ours and the method of counting them so as to make them correspond with the year was very complex, and the result unsatisfactory; there had to be frequent corrections to make the seasons come at the same time of the year. Yet nowhere in Greece was there ever discovered any way to obviate the inherent defect of their clumsy system. In different parts the months had different names, but were not divided like ours. There is a passage in the "Clouds" of Aristophanes in which the moon is represented as complaining of ill treatment because the Athenians had allowed their calendar to fall into confusion to such an extent that the gods were disappointed in their feasts. This made them angry with the moon—very unjustly, since the confusion in their reckoning was the people's fault. The case is very much as if we allowed our fourth of July to drift about until it ultimately came in cold weather. The lack of a fixed date for determining events gradually became generally recognized; consequently, as is generally supposed, Timæus, a Sicilian Greek, proposed the Olympiads as an era. The Olympiads, however, do not correspond with the era employed in Christian countries. Hence we have to use a rule like the following: "Multiply the complete Olympiads by four, and deduct the total from 776 for events of the autumn and winter, or from 775 for events of spring and summer." Although Timæus flourished as late as 300 B.C., earlier dates were made to correspond to his method of reckoning as well as it could be done. It is probable that much of the older chronology is erroneous. By means of observations taken on the star Sirius, both in Egypt and Babylon as early as the fourteenth prechristian century, the year was found to be about 365¼ days in length. Those old-time astronomers also reckoned by a lunar year of twelve months of 29 and 30 days alternately. This was merely a concession to custom. The moon is such a convenience for measuring periods longer than a day and shorter than a year that the incongruity between its phases and the sun's motions

was left out of account. The more intelligent people have become, the less attention they have paid to it. The defective year was brought a little nearer to the actual year by adding an intercalary month every three. The Babylonian year is supposed to have been introduced in Athens about 600 B.C. Half a century later the calendar was further improved by Cleostratus, but in all the Greek states the method of reckoning by days and months always remained a good deal wide of the mark. That the Roman year originally contained ten months is evident from the names of the last four called by them seventh, eighth, ninth and tenth (September, October, etc.), although they are in fact the ninth, tenth, and so on. July was named Quintilis, the fifth, August, Sextilis, the sixth; they were afterwards renamed in honor of Julius and Augustus Cæsar. The Roman calendar had, by the year 67 B.C. gone astray to the number of sixty-seven days, that is the civil and the solar year differed from each other to this extent. Julius Cæsar, with the aid of Sosigenes and M. Flavius, brought about the reform in the calendar which has remained substantially unchanged to the present.

The current arrangement of our calendar is a very stupid one. The seasons are not of the same length and the red-letter days fall on all the days of the week in different years. There are 186 days in the spring and summer seasons and 179 in the other two. It would be more rational to divide the year into four seasons each with 91 days and leave out of the count New Year's day and once in four years the extra day, calling it by some appropriate name, leap-year day, for example. The year should not begin where it now does, but either at one of the equinoxes or at one of the solstices. As the date, in the nature of the case, must be arbitrarily chosen it would thus at least have a scientific foundation. The calendar adopted by the French revolutionary junta was based on a scientific principle. The year began with the autumnal equinox of 1792 and consisted of twelve months of thirty days each with five complementary days, to which was added every six years an intercalary day. The months of the year with their names succeeded each other in the following order: Vendemiaire, Brumaire, Frimaire, Nivôse, Pluviôse, Ventôse, Germinal, Floréal, Prairial, Messidor, Thermidor, Fructidor. The month was divided into three decades. The days were named numerically, Primidi, Duodi, and so on. The fifth (Quintidi) and the tenth (Decadi) were designated as days of rest. The five or six complementary days were named Fête de la vertu, Fête du genie, Fête du travail, Fête de l'opinion, Fête des recompenses and Fête de la revolution. This calendar remained in force until January first, 1806, when that of Pope Gregory was restored by decree of Napoleon. Three Roman emperors after Augustus tried to substitute their own names for months instead of those in current use, but they were not permanently successful. Charlemagne also proposed to displace the heathen names

of the months by others that he considered more appropriate, but in this he also was unsuccessful. Christian Europe still clings to the names of the months as they were named by the Romans. It may be said, however, that in some parts of Germany February is known by the title given to it by Charlemagne. The change from old style to new was made by all the governments of western Europe except England and Sweden before the middle of the eighteenth century. In the former country, antipathy to the Pope and the natural conservatism of Parliament resisted a change until dates were eleven days out of the way. It was finally brought about under the Pelham ministry on the motion of Lord Chesterfield, who was, however, merely the "big-wig" put forward to give the measure prestige. He knew very little about the subject, but he knew his audience. Some time afterward he wrote to his son:

> I consulted the ablest lawyers and the most skillful astronomers and we cooked up a bill for the purpose. But then my difficulties began. I was to bring in this bill which was necessarily composed of law-jargon and astronomical calculation, to both of which I am an utter stranger. However, it was absolutely necessary to make the House of Lords think that I knew something of the matter; and also to make them believe that they knew something of it themselves, which they do not. For my part, I could just as soon have talked Celtic or Sclavonian to them, as astronomy, and they would have understood me fully as well; so I resolved to do better than to speak to the purpose, and to please them instead of informing them.

The change was, however, not so simple an affair as it might seem. A number of matters had to be regulated by law, especially rent-days, annuities and salaries. The year was henceforth to begin on the first of January instead of March 25, and September 2, 1752, was to be called the fourteenth. The populace was much disturbed by the shifting of the saint-days and immovable feasts. Lord Chesterfield's chief advisers were the mathematicians Macclesfield and Bradley. When some time subsequently a son of the former was a candidate for parliament one of the popular cries against him was: "Give us back our eleven days"; and when a number of years later Mr. Bradley died of a lingering disease, many persons attributed his sufferings to the part he had taken in changing the calendar. Verily, "Genius has its limitations, but stupidity has not." The ancient Romans, like the modern English gained the reputation of being an eminently practical people. But just as the latter cling to an awkward system of coinage, so the former adhered for centuries to a method of reckoning time that hardly passed beyond the stage of puerility. There is no evidence that they even divided the day into hours until the third century B.C. In the year 263 Valerius Messala is said to have carried away, among other trophies captured at the taking of Catania in Sicily, a sun-dial, which he set up in Rome. It was in use an entire century before even the officials be-

came aware that it was not correct for the meridian of Rome, although the latitude of Catania differs from that of the capital by more than four degrees. From that time forward sun-dials came into general use; and since many have been recovered their construction is well known. The most common form is that of a concave hemisphere cut in two. Within one of these quarters the hours were marked. A stylus or hand fastened in the top indicated the time of day, when the sun shone. Pliny says the first water-clock was set up in Rome 159 B.C. These water-clocks appear to have differed from the clepsydræ that had long been in use in the countries farther east. They consisted of an earthen vessel tapering downward to a point, in the bottom of which there was a small hole through which the water flowed in a given time. It was comparatively easy to ascertain when the sun was on the meridian; but not so easy to determine the exact period of midnight. This was moreover, an affair of small practical importance. In the larger cities, the periods or hours were announced by the sound of a trumpet; in the country few persons cared how the hours of the night passed. The custom of proclaiming the hours of the night prevailed in some countries of Europe, especially in Germany, long after clocks had come into almost universal use. It is not known when the Romans began to divide the day into twenty-four hours. At any rate there were two kinds of days in vogue: the astronomical day, the hours of which were all of the same length, and the civil or ordinary day which corresponded with the former at the equinoxes only. The popular day was a matter of latitude. In Rome the longest contains somewhat more than fifteen hours according to mathematical calculation, but owing to the Appennines which lie east of it the fact does not quite correspond with the figures. The hour in Rome was therefore at one time of the year about seventy-five minutes in length, while the hours of the night were correspondingly shorter, and *vice versa*.

Every schoolboy is taught that twelve inches make a foot, but not one in a million thinks to ask what is the basis of this measurement. It must at once occur to the occasional inquirer that the average human foot is not twelve inches long. When, however, a unit of measurement has been once fixed, the rest is easy. The metric system was the first attempt to establish an invariable standard to which recourse could always be had in cases of doubt. A table before me gives twenty-six different lengths for the foot in the German empire, twenty-five for the rest of Europe, eight for America and four for Asia. Of these the longest is that of Lombardy, which contains a little more than 435 millimeters, the shortest the foot of Siam, which is only 245.6 mm. Even in Germany the foot varies from 429.5 to 250 mm. There is of course the same divergence between the square and the cubic foot. The Eng-

lish foot contains 304 mm., which is usually held to differ slightly from that in vogue in the United States. Until there was a great deal of national and international intercourse the need of some uniform standard of weights and measures was not seriously felt; consequently the efforts of physicists in the seventeenth and eighteenth centuries did not receive much encouragement. Absolute accuracy in matters of this kind is unattainable, but in practical affairs it is not particularly difficult. What the term "accuracy" means to a maker of instruments of precision is forcibly illustrated by an anecdote told of John A. Brashear, of Pittsburgh. A prospective customer once asked him what it would cost to have a bar of glass made that was absolutely straight. Mr. Brashear would not promise absolute straightness, but was willing to come as near as he could for two hundred thousand dollars. After listening to a lecture on absolute accuracy by the renowned mechanician the customer concluded that his needs would be supplied by a ruler that would be correct to the one sixty-fourth of an inch and costing about forty dollars.

Physicists became convinced long ago that the only fixed standard of linear measure is some portion of the earth's circumference. No intelligent Greek or Roman from the time of Plato had any doubts about the shape of the earth. But after the Bible had come to be recognized as an authority in science as well as in doctrine the belief was gradually abandoned and various theories took the place of the true one until the time of Copernicus. Archimedes, about 200 B.C. used an ingenious argument to prove the sphericity of our planet. As water always seeks the lowest level the ocean must be equally deep everywhere and the bottom equally distant from a central point. As this is possible only in the case of a sphere, the earth must be spheroidal in form. The first attempt to calculate the circumference of the earth was made by the celebrated savant Eratosthenes in the third century B.C. Observing that the difference of latitude between two points in Egypt, Alexandria and Syene, was 7° 12′ and supposing them to be on the same meridian, and having ascertained as best he could that they were about five thousand stades apart, he reckoned this to be the fiftieth part of the earth's circumference, which would accordingly be 250,000 stades. More than a century later Poseidonius estimated the distance between Rhodes and Alexandria, on the testimony of seamen, to be five thousand stades, or one forty-eighth part of the circumference. Putting the value of the stade at six hundred feet—authorities vary considerably on this point—both estimates must be considered a remarkably close approximation to the truth.

In 1525 Fernel measured the distance between Paris and Amiens with a wheel. Almost a century later Snellius discovered, or rather rediscovered, trigonometry, which greatly simplified geodesy. By this

method he measured the distance between Alkmaar and Bergen-op-Zoom, using thirty-three triangles. He obtained nearly the same results with Fernel as to the circumference of the earth. Since that time similar work has been going on almost uninterruptedly. In 1669 Picard measured the meridian Amiens–Malvoisine, and from it estimated the circumference of the earth to be 20,541,500 toises or fathoms. Picard's figures were used by Newton in the studies which led to the discovery of the universal law of gravitation. At this point in the investigations the question arose whether the earth is a perfect sphere or a spheroid. In order to solve this problem two expeditions were fitted out, the one to operate in Peru, the other in Lapland. Both occupied several years, completing their labors about 1740. The results obtained settled for all time the relation of the polar to the equatorial axis. Geodetic surveys are, however, still in progress. The most extensive of the older projects was completed by Arago and Biot in 1808, based on the labors of Mechain and Delambre. The meridian measured was that between Dunkirk and Formentera, an island near the Mediterranean coast of Spain. This arc extended over twelve degrees and twenty-two minutes. The principal object of this survey was to establish a fixed unit of linear measure for the meter, which was to be the one ten-millionth part of the earth's meridian quadrant. This is the so-called *métre des Archives,* a platinum rod deposited in Paris. Although it is now known that it is not strictly correct there is no probability that it will ever be changed, as it has become the foundation of the metric system. In 1861 general Baeyer proposed the measurement of the meridian Christiania–Palermo. The work was to be carried out by the European governments conjointly. The proposal led to a general conference of savants in Berlin in 1862. A permanent commission was organized under the presidency of General Baeyer.[1] Another conference was held in Berlin in 1867, all the governments of Europe, except Turkey, having in the interval promised cooperation. Since then meetings of the commission have been held every two or three years, their object being the continuation and revision of the French measurements to Algiers, a complete triangulation of the Mediterranean Sea, the measurement of a parallel through Central Africa from Cape Town to Upper Egypt, and to take such other observations as usually fall within the scope of a geodetic survey. For many years the United States government has been engaged in measuring the ninety-eighth parallel which extends from the southern point of Texas to the Canadian border. Strange as it may seem in view of what they accomplished in several directions,

[1] The Prussian general Baeyer, who died in 1885 at the age of ninety-one, probably devoted more years to geodesy than any other man of modern times. He began his practical studies in 1816 and published his last work in 1881. He cooperated with Bessel in many of his measurements and astronomical observations.

the ancients had almost no knowledge of machinery. Water power was called into requisition to a limited extent, but the main reliance was on the muscular force of man and beast. In the East and in Egypt, the potentates tried to impress their contemporaries and posterity by the vastness of their structures; the artistic sense of the Greeks led them to make only such objects as were beautiful. But even the Romans who were intensely practical in most things never constructed labor-saving machinery. It is no explanation of the fact to say that actual or virtual slavery was the cause of this lack of enterprise. The same conditions prevailed throughout the Middle Age after slavery had been to a considerable extent abolished. Machinery can hardly be said to antedate the era of steam. Although time-pieces can not properly be called machines, their construction requires a knowledge and appreciation of the mechanical powers. It is in strict conformity to the law of progress that water-power which had been in use for purposes of propulsion for thousands of years should also be employed in the manufacture of time-pieces.

We need to be often reminded that the phrase "to save time" is one of the most frequently misapplied in our language. If we can cross an ocean or a continent in five days instead of the fifty formerly required, where have we saved any time, if we make no good use of the forty-five we are supposed to have saved? If we can converse with a person ten miles or a hundred or even a thousand miles distant without stepping out of doors, where is anything gained if we have nothing to say that is worth saying? If by means of so-called labor-saving machinery we are provided with a thousand pages to read for every one that was within easy reach of our grandfathers, how are we better off if very little of it is worth reading? We are losing rather than saving time in the operation. The truth is that nothing worth doing has ever been done in a hurry. Almost all the great discoveries and inventions that have really benefited mankind are the result of much patient thought and investigation and experiment. The same is true of every work of art, whether pictorial or plastic. After they have become public property their use is a mere matter of routine and imitation. The more time we "save" the less we seem to have. The more we rely on machinery to do our work, the more nearly we become machines ourselves. Even our educational processes have largely degenerated into mere mechanical routine. Each pupil and student is taught to do what he has seen others do. Most of our young people are advised to transform themselves into living cash-registers as early as possible, although the coins they handle are for the most part either counterfeit or of small value.

PROFESSIONAL TRAINING FOR CHILD HYGIENE

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NO one acquainted with the problems of professional education can read Mr. Abraham Flexner's exposé of the status of medical education in the United States and Canada without a feeling of profound gratitude. His description of conditions is so masterly and variegated as to give the impression of utter completeness. It would seem that nothing had been forgotten. On further consideration, however, this appears far from being the case. Mr. Flexner has confined himself to an exposition of the shortcomings of medical education with exclusive reference to the ideals, purposes and standards of the best present-day medical schools. The social sufficiency of these ideals and purposes he seems to take for granted. For him, as for the practising physician, the main business of medical education is to train men in the scientific diagnosis and therapy of existent disease. The yet more important duty of the medical school to train men for scientific work in the several prophylactic fields of child hygiene is not even suggested. Let us glance briefly at this neglected aspect of preventive medicine.

Civilization has necessitated a tremendous readjustment of life habits. The factors which controlled and directed the evolution of the human organism have in large part become inoperative. Our modes of sedentary life tend less and less to bring into play the physical traits which were of most teleological value in the primitive struggle for existence. Instead, excessive burdens are laid upon functions and organs never intended by nature to endure them. If only the intentions of nature were respected during the period of growth and development the problem would by no means be so serious. The youth who had been brought into possession of his full psycho-physical inheritance would be in a position to conserve this inheritance in the face of great odds. This we do not permit. The introduction of universal education has changed the whole life of the child from one of active to one of sedentary occupation. As stated by Gulick, "so extensive a readjustment of the life habits of the young of a species has never before been attempted." Nor is it reasonable to suppose that man presents any exception to the biological law that the ultimate survival of an organism is threatened whenever it is subjected to conditions of environment widely different from those which directed its evolution. We have taken the child out of its natural habitat of open air, freedom and sunshine and for half his waking hours we are subjecting him to an

unnatural regimen which disturbs all the vital functions of secretion, excretion, digestion, circulation, respiration and nutrition. Even the very anatomy of the bones themselves, both gross and fine, is markedly affected.

The fact that the school doctor has been called in to examine and advise does not signify that the gravity of the situation has been apprehended. Teachers have simply found physical defects an impediment to the pupil's school progress and desire their removal. The school doctor spends some three to six minutes in the examination of each pupil, looking only for the gross and external symptoms of defectiveness. Having strictly the point of view of the physician, his search is for disease. His training has not fitted him to scent out delicate, incipient deviations from the normal nor to see the necessity of doing so. He does not have a biological conception of the functions of child hygiene. To appreciate the importance of the school health officer we need only to enumerate some of the problems most in need of investigation by men scientifically and specifically trained for the purpose. The following are some of these questions—not one of which can be satisfactorily answered in the light of our present information.

What is the exact nature and extent of the effects of school life upon the vital processes and upon growth? What changes, for example, does the child's blood undergo during the school year in number of red and white corpuscles and in percentage of hæmoglobin? What happens to the blood during a well-spent summer vacation? How does the sedentary work of the school affect the growth of the heart and its muscular force? How common is malnutrition among school children, and what are its causes? To what extent is the school responsible for the curse of constipation? What is the relation of book work to lung capacity, and just how seriously does sub-normal lung capacity menace the future health of the child?

What physiological changes are induced by the high temperature and low humidity of ordinary school-room air? Is it true, as recent experiments suggest, that the goal for which the mechanical engineer strives in the ventilation and heating of a school building, that is, the maintenance of an absolutely even temperature and the avoidance of perceptible draft, is the worst possible condition that could be secured? Is it true that keeping the relative humidity of the schoolroom air up to 50 or 60 per cent., the temperature down to 60 degrees or below, and permitting perceptible drafts which will keep the skin practised in the exercise of vaso-motor control should be matters of far more concern than avoiding the usual slight depletion of oxygen or the excess of carbon dioxide? Is respired air poisonous? If so, by virtue of what properties?

What are the special characteristics of school dust? Which kinds are most injurious? What part does dust play in the dissemination of

school diseases? What are the exact results following the introduction of the vacuum cleaner in the school? What are the indirect effects of pure air on the processes of nutrition and growth? Can school air be made hygienic? What results from the combination of deep breathing and dust in the average indoor gymnasium? Is exercise thus taken better in the long run than none at all?

Is it true, as certain recent researches suggest, that forty or fifty per cent. of all school children contract tuberculosis at least once before the end of the school course? How does the incidence of tuberculosis among school children vary with different climatic, social and industrial conditions, and with different methods of school sanitation? Probably two million children now in our public schools will die of this disease. Would systematic researches make possible the earlier diagnosis of active cases, or even the certain detection of constitutional predisposition to the disease? Does any one know that we could not by segregation of such pupils in open air schools and by carefully regulating their diet save the lives of half or three fourths of this two million?

What produces hypertrophied tonsils and adenoids? Are they connected with the disturbances of lymphatic circulation and of nutrition due to the sedentary school life? By what mechanism do they produce such deplorable stunting effects on body and mind? To what extent, as statistically determined, do they predispose to tuberculosis and other throat and lung diseases? Are they a necessary incident in the growth of 10 or 15 per cent. of our children? Is it sufficient merely to wait for their appearance and then call in the school doctor to remove them?

What is the relation of the school to the neuroses? Is the school a factor in the undoubted increase of insanity? Does school overpressure, as some psycho-pathologists believe, lay the last straw in the case of those predisposed to neurasthenia, hysteria, or dementia præcox? Of the 18,000,000 children now in the public schools, the lives of probably a half million will be rendered miserable failures because of one or another of the neuroses. May we hope that scientific research in the etiology of nervous diseases will make it possible to segregate the "emotive" cases and apply a psycho-prophylaxis which shall lead them to a normal mental life?

Over half of the pupils fail to progress through the grades at the expected speed. What are the causes of retardation? To what extent is it an expression of congenital mental deficiency? How many mentally deficient children are in our schools? What are the respective values of heredity and environment in the etiology of feeble-mindedness? How common is the *moron,* that is, the grade of intelligence lying between the merely "dull" and the "feeble-minded"? What proportion of morons become criminals? What kind of education must they receive to insure that they shall not become social burdens or pests? By what means shall we classify them and on what bases?

What connection, if any, has moral instability to such physiological abnormalities as impacted teeth, irritating conditions of sexual organs, nasal occlusions, intestinal parasites and circulatory stagnations due to over-much sitting? What is the relation of mental and physical deficiency of children to alcoholism, syphilis, tuberculosis, or long continued dietary insufficiency during the period of growth?

What is the relation of oral hygiene to general health? What factors underlie the individual differences of children in predisposition to dental caries? How is this "disease of the people" related to nutrition, both as cause and effect? How is it related to school progress and morals? Is Osler justified in asserting that the problem of oral hygiene is of more consequence to racial welfare than is the alcohol problem?

What influence upon educational practise may we expect from the modern methods of roentgenographic determination of anatomic and physiological age differences? How large are such differences among children of the same chronological age? Does mental growth correlate with skeletal development, or with physiological age as determined by dentition and sexual maturity, or with chronological age, or with none of these? Current methods of promotion tend to a gradation by chronological age. Is it certain that this has more to commend it than a classification on the basis of height or weight? What percentage of school failures is due to subnormal physiological maturity? Should we always appeal to the roentgenograph to help decide doubtful cases of promotion? How frequently is nervous overstrain connected with a neglect of physiological age differences?

What are the physiological effects, *ultimate,* as well as immediate, of current methods in physical training? How are we to explain the surprisingly unfavorable showing of athletes in life-insurance statistics? Is it frequently justifiable to subject children to "corrective" gymnastic exercises in preference to free play? Just how, physiologically, does exercise which is enjoyed differ in its effects from exercise which is not enjoyed? Is the difference comparable to the difference found by Pawlow in the secretion of saliva and gastric juice under varying emotional conditions? What sports can safely be indulged in by children of different ages? Can any one state authoritatively what percentage of 16-year-old boys ought to attempt the five mile run? Might not research (research along these lines is now as rare as it is precious) teach us more reliable methods of diagnosticating athletic fitness and unfitness? (Professor Clark Hetherington is authority for the statement that not one physician in a thousand can make this determination.) What are the permissible limits of athletic specialization? What is the relation of muscular power to mortality and morbidity? Is current playground and gymnastic instruction sufficiently differentiated for age and sex differences? How far may physical training

for girls safely be modeled after that for boys? What time in the day should exercise in physical training be given? How should it alternate with other school studies? Can it ever safely replace the old-fashioned free "recess"? Just what does it mean, physiologically, for a muscle to be "trained"? Which of the half dozen or more theories is the correct one? How far can training be bunched? Does training produce fatigue bodies and anti-bodies, as Weichardt thinks he has demonstrated?

How many hours daily should children study? Can any one disprove Dr. Weir Mitchell's assertion (which seems to be the belief of most psycho-pathologists) that children could accomplish as much as they do now if the school day were only half as long? What is the most favorable alternation of work and rest periods in mental hygiene? What is the diurnal course of mental (also moral) efficiency? When is the assignment of home study justifiable? How do the results of home study compare in quality and quantity with school study? Is there much or little ground for the frequent charges of overpressure made against the schools? Is school overpressure responsible for any of the recent and marked increase in child suicides?[1]

Investigations into the sleep of school children show that they sleep on the average nearly 25 per cent. less than "authorities" have usually set as a safe norm. Is there a real sleep insufficiency of 25 per cent., or has the amount needed been overestimated? In the matter of sleep what are the safe limits of habit adaptation? What is the relation of sleep to school progress, nutrition, morbidity and conduct?

The human eye was evolved to satisfy the demands of *ordinary* vision—that is, to make on the average 15 or 20 movements per minute, under conditions which permit frequent shifts of accommodation and convergence. The work of the school demands of the immature eye that it execute for several hours a day an average of 150 to 200 separate movements per minute with as many rifle-aim fixations and with a uniformly intense strain of the muscles of accommodation and convergence. What is the relative importance of these factors as compared with heredity in the etiology of ocular defects? How does malnutrition affect the eye? How much truth is there in Dr. George M. Gould's assertions regarding the reflex effects of eye-strain upon general health? What is the minimum size of type that should be permitted for children of different ages? What are the optimum norms for width of stroke, spacing of letters and words, length of lines, color of paper, and intensity of light? Is the complete conservation of vision possible?

What conditions of health obtain among the one-half million school teachers in the United States? What kind of physical constitution

[1] See Albert Eulenberg, "Schülerselbstmorde," *Zt. f. Päd.-psych.*, 1907, pp. 1–81. Also Louis Proal, "L'éducation et le suicide des enfants," Paris, 1910.

does the profession attract? How many are tuberculous? What proportions suffer from insomnia, obsessions, neurasthenia, eye-strain, headaches, heart-disturbances, indigestion, constipation, or other functional derangements? What constitutes overwork of the teacher, and what are its reflective effects upon the pupils? What is the status of personal hygiene practise among teachers? How many of them are in the "patent-medicine-stage" of ignorance? What fraction of them do not appreciate the difference between an oculist and an optician? Is it vain to hope that our half million teachers may yet be made so many missionaries of public health? If so, through what methods of teaching hygiene in the schools? How do different methods of teaching physiology and hygiene differ in their effects upon life habits? What is the best approach in teaching "scientific temperance," or the still more difficult subject of sex hygiene? Should the latter be taught in the public school? At what age? What should be the content of such instruction?

The greatest problem of conservation relates not to forests or mines, but to national vitality, and to conserve the latter we must begin by conserving the child. *Let it again be emphasized that hardly a single one of the above questions is fully answerable to-day.* Not many of them will be fully resolved until they have been attacked on a broad scale by systematic and scientific methods of research. To secure proper scope for such research the schools must be thrown open to it; to insure adequate support it must be made a public undertaking. The school instead of causing sickness and deformity must be made to preserve the child from all kinds of morbidity, repair his existent deformities, combat his hereditary predispositions and the bad conditions of his social environment, in a word fortify his constitution and render him physically and mentally fit for the struggles of life. The value of research carried on for this purpose will depend most of all upon the type of man intrusted with it. The teacher can not do it; the superintendent or principal can not do it; no more can the average school physician.

Who is the school physician and what has been his training? With a few notable exceptions he probably differs little from the average practising physician, and since the merciless brochure of Mr. Flexner it is unnecessary to dwell at length on the positive unfitness of the *average* physician for any research, to say nothing of the highly specialized kinds here advocated. Suffice to say that Mr. Flexner finds only about 30 respectable medical schools in the entire country; that twenty years ago there was not one; that a large fraction of our physicians "walked into the profession from the street"; that over one half the schools require less than a high school-course for entrance; that half or more have little or no laboratory facilities for physiology, pharmacology or bacteriology; that many do not even teach the use of

the microscope; that the teaching of anatomy and pathology is often entirely didactic; that clinical facilities are usually inadequate and in many cases practically lacking altogether; that many are squalid, "reeking with commercialism," and "without a redeeming feature of any kind." Such has been the making of a large numerical majority of our physicians. Additional comment would be superfluous.

But what of those physicians whose medical training, as such, is above reproach? It would be unjust to confound them with the average practitioner who is ignorant alike of the principles of medical science and of child hygiene. Nevertheless, it must be said no less emphatically that the ideal equipment for the school health officer is vastly different from that required for the successful practise of medicine. The physician is "long" on certain qualifications of little value to the school health supervisor and as much "short" on others extremely important. When he enters the school he leaves his obstetrics and his pharmacology behind. On the other hand, he needs to know a great deal about such questions as those propounded in the first half of this article, the solution of many of which is in no way made easier by the best medical equipment. As a matter of fact and common sense, if the work of the school health officer is to remain confined to the hasty and superficial kind of examination usually given by the "medical inspector," then we had better forego the luxury of physicians and employ trained nurses instead. After a few months apprenticeship the nurse could make the usual tests of sight, hearing, etc., as well as the physicians are making them. Already in some of the large cities (San Francisco and Oakland, for example) nurses are actually doing, under supervision, practically all the routine work of examinations. As for the ordinary tests of vision, the teacher of average intelligence can make them as successfully as the *physician who is not also oculist.* A considerable number of the best oculists in the country have officially taken this stand.[2] The point is not that the work should be narrowed to what the teacher can do, but rather that it should be extended beyond the functions of the physician.

The physician, after all, is only a physician, which is as much as to say that he is not a hygienist in point of view. He has learned something of the science and art of discovering and curing disease. At best he has also learned a little of the general principles of preventive medicine, but of the many special relations of preventive medicine to the school he knows extremely little. He is ignorant of the technical aspects of education, of child psychology, of the psychology of mental deficiency, and of a host of common developmental abnormalities. If he knows anything of mental hygiene and psycho-prophylaxis it is not to the credit of his medical school, for not a half dozen in the country have yet taken any account of the late epoch-making developments in

[2] See Gulick and Ayres, "Medical Inspection of Schools," pp. 105–6.

psycho-pathology, wrought by such investigators as Freud, Jung, Prince, Sidis and Adolf Meyer. The situation may be summed up in a sentence: *The physician's training does not qualify him for the many sided task of adapting the program and environment of the school to the health and growth needs of the pupil.* The main purpose of this article is to suggest tentatively and somewhat roughly some of the more important lines of professional preparation necessary for those who are to work in any field of child hygiene in the public schools.

Educational hygiene has four chief aspects: (1) "Medical Inspection," including routine examinations for physical defects and consequent follow-up service; (2) supervision of physical training, including free play, gymnastics, and athletic sports; and (3) child psychology, including clinical work with mentally and morally atypical children, the hygiene of instruction, etc.; (4) researches in school heating, lighting, ventilation, seating, sanitation and other externals affecting the health of the child. Each of these divisions has of course its logical subdivisions but as only the very largest cities could employ a more specialized staff than this scheme calls for it is unnecessary to carry the classification further. On the other hand, the majority of school health officers will probably for some years to come have to serve more or less in all these capacities. Assuming, however, the four separate lines of specialization above designated let us examine the general and special courses of study which would be necessary for their successful pursuit.

To begin with, it would seem that the time requirement could not reasonably be placed below seven years in addition to a four year high school course. This corresponds to the usual allotment for the doctorate of philosophy and to that for the doctorate of medicine in our sixteen best medical schools. Using the seven-year basis for our calculation, the course falls naturally into three divisions. The first three years would be given to regular college work in which the elements of physics, chemistry, biology, physiology, psychology, paidology, sociology and at least one modern language would be taught. The next three years would be ample time in which to give all that is needful *for the school health officer* out of the present medical curriculum, besides leaving a fair margin for collateral work in psychology, paidology, and the technical aspects of education. The last year would be reserved for carefully supervised clinical practise in the public schools. Proof of ability to read both French and German should be required a year before the end of the course, for most of the important researches in school hygiene are in these languages.

Physicians will of course object to the time allotment for the second division. How, they will ask, can you condense a medical course into three years, to say nothing of a margin to be left for psychology and paidology? The answer is more in terms of elimination than of condensation. Pharmacology, materia medica and therapeutics can be dis-

carded in a lump, with a consequent saving of a full half year. Doing the same for the obstetrics, gynecology and most of the surgery effects a further saving of three-quarters of a year. This makes a year and a quarter off the present medical course. Further, for the purpose here in question, minor savings could be effected in several subjects, as, for example, anatomy, in which the minimum of 400 hours required by the best medical schools could here be taken for the maximum. Finally, the additional year of clinical experience in the schools would take the place of most of the usual courses in the hospital and dispensary, so that almost half of the second three years would be left for psychology, paidology, education, sociology, school hygiene, gymnastic sports, etc., the amount of each being dependent upon the student's choice among the four special lines above named: medical inspection, clinical child psychology, physical training and school sanitation. Throughout the course time would be saved and effectiveness promoted by never losing sight of the professional nature of the courses. Physiology, pathology and bacteriology, as well as psychology and sociology, would have to be taught in their relations to the ultimate work to be done, not as so many unitary and complete sciences. Even the first three years ought to be conscious of the professional end.

A school health officer, the product of such a school, would be of far greater service to education than is the usual school physician and would probably be worth more to society in the long run than a dozen well-trained practitioners. At least one such specialist in child hygiene is needed for every 2,000 school children. California needs 200, the United States at least 7,000. What university will be the first to undertake their production?

Finally, could men be found in sufficient numbers who would be willing to pay the price in time and strenuous effort involved in such a training for the modest remuneration the schools would offer? No reason appears why there should be any dearth of candidates. The pay frequently ranges from $2,000 to $3,000 per year and occasionally goes as high as $4,000. Medical inspection, though spreading at a tremendous rate, is still new with us, and doubtless as the profession becomes more specialized and more standardized it will receive as well as merit higher remuneration. As things are, it compares not unfavorably with professorships in colleges and normal schools, for which we have a constant oversupplying of young Ph.D. candidates willing to serve an indefinite period of apprenticeship as underlings, if only the coveted promotion with permanency of tenure can be reasonably hoped for in the end. Indeed, the rising young profession compares in its rewards not unfavorably with the practise of medicine itself, thanks to what Flexner calls the "enormous over production of physicians."

THE FOUR PERIODS IN THE DEVELOPMENT OF THE MODERN ZOOLOGICAL SYSTEM

By Professor H. S. PRATT
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IN 1758 when Linnæus published the epoch-making tenth edition of his "Systema Naturæ" the science of zoology was in a backward condition, having made but little progress for a long period of time. Some important advances, it is true, had been made by the generation immediately preceding that event. Trembley and Peysonnel had proved the animal nature of *Hydra* and of corals; Linck and Klein had increased the knowledge of the obscure group of echinoderms; Réaumur had continued the brilliant researches of Swammerdam on insects. The discovery of microscopic animals, also, in the preceding century, had opened up new vistas, into which, however, the scientists of the day saw as yet but dimly. Zoology was still, notwithstanding these things, a very crude descriptive science, in which but few fruitful attempts at comparative or philosophical studies had been made.

The cause of this failure to progress rapidly was not the lack of able and earnest zoologists in the preceding ages or even the absence of new discoveries, but the chaotic condition of the zoological classification and nomenclature, which stood in the way of the recognition of the true relationships of animals. A chaos could not become the basis of a system of philosophy. When thus in 1758 Linnæus introduced his fully developed binomial system and arranged all the animals then known to science according to its rules into classes, orders, genera and species he provided the key which should unlock the mysteries of zoology as a science, and disclosed the wonders it contained.

The essential feature of this system and that which was new at the time was the giving to each species of animals of two names, instead of one, or of several, one of which was the specific name and the other the name of the next higher subdivision in the classification, the genus. The other important features were the precisions of the terminology employed, which enables the author to characterize a species in a few words, and the natural arrangement of the classification in which the position of each species indicates the degree of its genetic relationship to all the others.

It is true that predecessors of Linnæus had anticipated many features of his system. The idea of a species was already well fixed before his time and efforts were made to characterize those then known and

the new ones which were constantly being discovered. But the names given were often complex and cumbersome and no uniformity existed between the systems of terminology of different authors. Also the custom of giving two or more Latin names to a species was frequently in vogue, but a binomial system, with the definite relation of the specific to the generic name, was new. The genus, which gives the clue to the natural affinities of the animal, was peculiarly Linnæus's invention.

Attempts had also been made by Ray and Kleinf and other advanced thinkers to form a system which should express the natural relationships of animals, but such attempts were generally not understood or followed and most authors still employed unnatural methods of arranging them. Many still followed Pliny and grouped animals according to the environmental conditions surrounding them, placing those together having similar methods of life, as land animals, freshwater animals, marine animals, flying animals, etc. Within each group the species were often arranged in alphabetical order.

Linnæus's system was very quickly accepted by the scientific world and went into universal use, and modern zoology may in a very real sense be said to begin with the year 1758.

So radical, however, was Linnæus's reform that neither the superiority of his system nor the simplicity of his terminology would probably have been sufficient thus to procure its adoption if they had not been proposed by a man of his great fame and commanding position in the world. Linnæus was considered by his contemporaries, because of his numerous and important contributions to science and his eminence as a teacher in the University of Upsala, as the greatest naturalist of all time. His importance was indicated by the phrase in vogue: Deus creavit; Linnæus disposuit.

The immediate acceptance of the Linnæan classification had the same effect upon the study of animals and plants in his day as that of Darwin's theory of natural selection had almost exactly one hundred years later. It gave a tremendous impetus to every branch of biological investigation and started a new era. Systematic zoology, morphology, physiology and experimental zoology all attracted able investigators who studied them with feverish activity. Comparative studies first became possible, as now the facts of the science were for the first time arranged in something like an orderly and natural manner, and the next generation saw the rise of the sciences of comparative anatomy, paleontology and comparative embryology, and also the first modern speculations on the blood relationships and the evolution of living things.

All these things gave a new importance to zoology and raised it from the position it had occupied of a mere annex to medicine to the dignity of an independent science.

Linnæus divided the animal kingdom into six classes: Mammalia,

Aves, Amphibia, Pisces, Insecta and Vermes. The knowledge of this last class, which included all invertebrate animals except the arthropods, was in a very confused state, and one of the chief objects of the many able zoologists of the generation immediately following him was to remedy this condition. The men whose services were greatest in this direction were O. F. Müller, Lamarck and Cuvier. In 1794 Lamarck first distinguished the vertebrates from the invertebrates and subdivided the latter group into the five classes of Mollusca, Insecta, Vermes, Echinodermata and Polypi. Thus a long step was taken towards modernizing the system and this early effort of Lamarck may be said to be the first modern classification of animals. He, in his later works, further subdivided the invertebrate types until he had ten, the fundamental idea at the basis of his classification being that the various groups of animals constitute a single ascending series which begins with the lowest and ends with the highest. This principle of the unity of the type found a wide acceptance among the naturalists of that time and was based upon the law: Natura non facit saltum.

In 1812 Cuvier published his division of the animal kingdom into four branches or types and in 1817 his great work "Le Règne Animal" which established the second great reform of the system and was destined to exert an influence only second to that of Linnæus's "Systema Naturæ" upon the study of animals and the development of the system. In these works Cuvier controverted the principle of the unity of type among animals and taught that instead of one four distinct and permanent types prevail. It was upon these four types that he based his four fundamental branches of the animal kingdom: Vertebrata, Articulata, Mollusca and Zoophyta or Radiata.

A comparison of this classification with that of Linnæus will show what a tremendous advance had been made in the development of the system in the half century separating them. The group of animals which had benefited most in this general advance was probably the Mollusca, which was Cuvier's special field of research. The lowest group in Cuvier's system, as that in Linnæus's, was the one about which the least was known, the Zoophyta or Radiata being made up of several distinct and heterogeneous groups of animals which bore no near relationships to one another.

This condition led to an active investigation during the generation immediately following of all the lower animals and a very large number of works of fundamental importance appeared. Rudolphi studied the parasite worms, Tiedemann and L. Agassiz the anatomy and Johannes Müller the development of echinoderms, Ehrenberg the microscopic animals, Eschscholtz, Sars and others jellyfish and polyps. The knowledge of these two latter groups was also very much extended as the result of various scientific expeditions which were sent out by

the French, English, Russian and American governments to different parts of the world, especially to the tropical oceans. Of these voyages perhaps the most interesting were that of the Russian ship *Rurik* from 1818 to 1820, in which Chamisso and Eschscholtz went as naturalists and discovered the alternation of generation of *Salpa,* that of the English ship *Beagle* between 1831 and 1835 with Darwin as naturalist, and the American expedition under Captain Wilkes between 1838 and 1842 with James Dwight Dana as the principal naturalist.

The influence of all these investigations, and also of the newly established cellular theory of the structure of plants and animals, on the development of the zoological system led to the third great reform of the latter. In 1845 von Siebold subdivided Cuvier's fourth type, the Zoophyta or Radiata, into three types or phyla, the Protozoa, Zoophyta and Vermes, confining thus the term Zoophyta to the truly radiate animals. He also broke up Cuvier's second type Articulata, removing the Annelida to the new phylum Vermes and creating another new phylum for the Crustacea, Arachnida, Myriapoda and Insecta which he called the Arthropoda. Two years later R. Leuckart broke up the Zoophyta, subdividing it into the phyla Echinodermata and Cœlenterata, and emphasized the isolated position of the Protozoa, and a little later Milne-Edwards added still another new type or phylum, the Molluscoidea, in which he included the Bryozoa, Brachiopoda and Tunicata. The animal kingdom was thus in 1850 subdivided into eight phyla, the Protozoa, Echinodermata, Vermes, Arthropoda, Molluscoidea, Mollusca and Vertebrata, an arrangement which is still found in many text books.

Darwin's "Origin of Species" was published in 1859 and the fourth and last important reform of the zoological system of classification was the direct consequence of the doctrines therein promulgated. The theory of the common descent and blood relationship of all animals which Darwin taught was at variance with Cuvier's theory of fixed types and in harmony with Lamarck's theory of the essential unity of the animal kingdom, and was first employed by Haeckel as the basis of a system of classification. In 1877 he called attention to the need of placing the entire system on an evolutionary basis and at the same time subdivided the animal kingdom into the two great groups of the Protozoa and the Metazoa, and the latter into the two great groups of the Cœlenterata and the Cœlomata. In still more recent times other authors, notably Hatschek, following Haeckel's lead, have carried the subdivision still further on the same basis. The old idea of types, however, has a very tenacious life and is still the basis of the classification of animals in most text-books—and probably rightly so. For most animals, notwithstanding their ultimate relationships with one another, can as a matter of fact be grouped in a number of distinct types or

phyla, each of which has a characteristic plan of structure. Cuvier's belief, however, that these types are fixed and isolated creations, has long since been abandoned.

Very important has been the formation in recent times of the phylum Chordonia or Chordata, which brings under the same subdivision all the animals possessing the essential characteristics of the vertebrate type. The formation of this phylum has been due to the fundamental researches of Kowalevsky, who in 1866, 1867 and 1871 gave the first detailed and accurate description of the anatomy of *Balanoglossus* and also the first detailed accounts of the embryology of ascidians and of *Amphioxus,* showing that these animals are related to one another and to vertebrates. The term Chordonia was introduced in 1874 by Haeckel to include the Tunicata, *Amphioxus* and the Vertebrata and the terms Urochorda and Cephalochorda by Lankester in 1878 for the Tunicata and *Amphioxus.* In 1884 Bateson, on the basis of his researches on the American form *Balanoglossus aurantiacus,* added the Enteropneusta to the Chordata and proposed the term Hemichorda.

The system of zoological classification was thus fixed some twenty or thirty years ago and has undergone no important changes in its larger features since. This is not true, however, of many of the subordinate and smaller of its groups, the arrangement of which changes from time to time as the knowledge of the relationships of the animals composing them increases. We find this to be especially true of certain low animals which seem to be isolated side branches of the ancestral tree, the origin of which from the main stem is still obscure.

Each of these four distinct periods of reform of the modern zoological system has been inaugurated by one or two eminent men of great constructive powers who have been able to see deeper into the significance of facts than their predecessors and contemporaries and to interpret rightly those which they have gathered. The first reform was started by Lamarck and the second by Cuvier, the third by von Siebold and Leuckart and the fourth by Darwin and Haeckel.

FLORENTINO AMEGHINO

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IN the death of this distinguished paleontologist science has sustained a heavy loss. Our knowledge of the splendid succession of fossil mammalian life in the Argentine is due principally to the work of Ameghino. A collector and explorer whose energy and enthusiasm no handicap of opposition and poverty could overcome, a student of immense learning and keen insight, a writer and controversialist of extraordinary facility and dialectic skill, a broad thinker and daring speculator, above all a man of high ideals and great patriotism, his life and achievements are well worthy of admiration and respect.

Ameghino seems to have interested himself in fossils from boyhood. In 1880, while still, it would seem, in the early twenties, he had already spent ten years of his life in collecting fossil mammals in the Pampean formation in the vicinity of Buenos Aires, and especially in searching for evidences of man contemporaneous with these extinct animals. His conclusions as to the antiquity of man had received notice in the local journals as early as 1875, but had failed to secure the endorsement of the heads of the two great Argentine museums. Failing this endorsement at home, he sought to secure it abroad, and in 1878 exhibited at the Paris Exposition a great collection of archeologic and paleontologic remains. (The fossils were purchased by the late E. D. Cope and later came into possession of the American Museum of Natural History in New York.) Fortified by the support received abroad, Ameghino published in 1880–81 a two-volume brochure entitled "La Antiguedad del Hombre en La Plata," in which his views were set forth in full, together with a history of the controversy.

In succeeding years his time was given more and more to researches in the older formations underlying the Pampean, and to the collection and study of the wonderful mammalian faunæ which they contained. To explore these formations, lying mostly far to the southward, 500 to 800 miles from Buenos Aires, involved long expeditions on the part of Ameghino's younger brother Carlos, the elder brother remaining at home to earn the necessary funds for his own and his brother's support through a small stationer's shop which he kept in La Plata. Year after year these expeditions continued, and their results were published by Florentino in a flood of descriptive and controversial papers, amazing

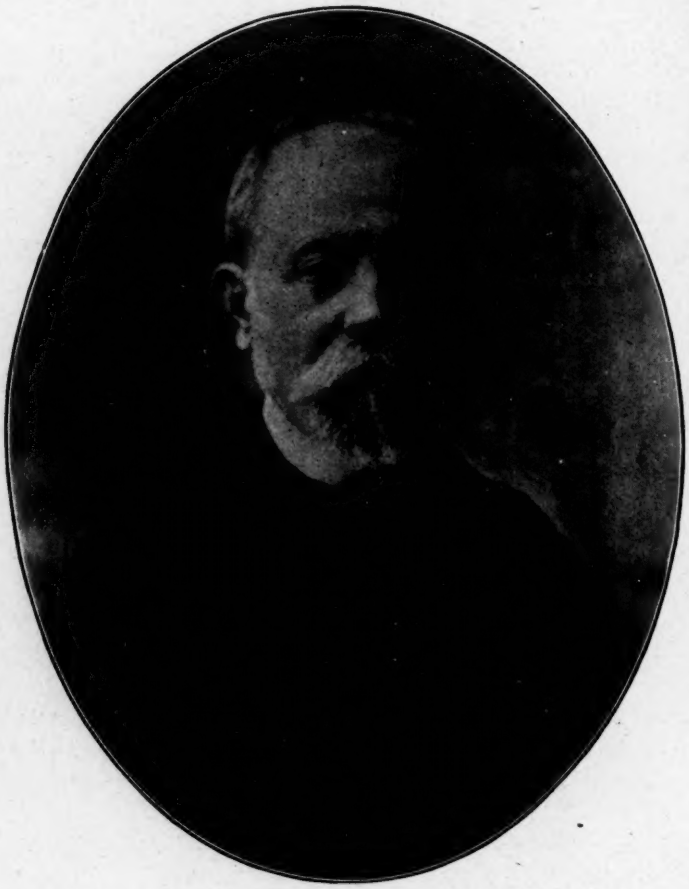


FIG. 1. PORTRAIT OF FLORENTINO AMEGHINO, October, 1910.
Courtesy of W. J. Sinclair.

in volume, learning and acrimony. In 1889 he published a revision of the fossil mammals of Argentina in two large quarto volumes abundantly illustrated. During thirty years of work Ameghino described over 500 new genera, with probably some thousands of species of fossil mammals.

These papers made known to science a whole new world of animal life. The Tertiary mammals of South America were as different from those of the rest of the world as is the modern Australian fauna, and for most of our knowledge of them we are indebted to Ameghino. Besides the Santa Cruz with its wonderful riches of fossil mammals, he described a series of older faunas no less interesting. That so much should be accomplished by one man is remarkable enough. It is far more remarkable that he should achieve so much in spite of straitened means, and bitter official opposition, which he had, it must be admitted, brought upon himself by his vehement, combative and controversial

abundantly illustrated, describing new discoveries and supporting and

spirit. Some of his work, indeed, appears hasty and ill-considered, and its value seriously marred by a partisan and contentious maintenance of theoretic conclusions which most paleontologists have found it impossible to accept. Ameghino regarded the age of the later formations of Argentina as much greater than his confrères in Europe and North America could admit, and maintained views in regard to the phylogeny and derivation of the Tertiary faunæ, which, however skilfully defended, are not likely to find acceptance. But these peculiarities of theory and temperament should not blind us to the immense value and interest of his discoveries, nor to the vast learning and indefatigable industry with which they were brought before the scientific world. Nor should they prevent due meed of admiration to his enthusiasm and energy and sincere love of science. It is pleasant to record that even in his earlier years he had won his way to the high respect and honor of his fellow citizens and to an admittedly high standing abroad. He occupied for a time the chair of zoology and comparative anatomy in the University of Cordoba, and in 1886 was appointed secretary and subdirector of the La Plata Museum, but resigned this post two years later owing to differences with the director, Señor F. P. Moreno, and for ten or twelve years afterwards seems to have held no important official positions. In 1902 when the directorship of the Museo Nacional of Buenos Aires became vacant, Señor Ameghino was appointed to this honorable post. Under his direction the museum has shown great vigor and activity, while his researches bore fruit in a series of publications, now

FIG. 2. THE "RIVADAVIA" STATIONER'S SHOP IN LA PLATA.

Courtesy of Professor W. B. Scott.

From the management of this business Ameghino secured the means to carry on his great researches in Argentine paleontology, and to maintain numerous expeditions by his brother Carlos into central and southern Patagonia.

ficial, whatever conclusions it leads to. In this field he stood forth as

abundantly illustrated, describing new discoveries and supporting and elaborating his stratigraphic and phylogenetic views.

His untimely death in August, 1911, is stated to have been due to blood poisoning from a neglected wound.

Through the courtesy of Professor W. B. Scott and Dr. W. J. Sinclair I am enabled to illustrate this notice with a portrait of Dr. Ameghino, and with views of the shop which supplied the funds for his explorations and the little workshop and study where his collections were installed and the greater part of his monumental researches were

FIG. 3. AMEGHINO'S WORKSHOP AND STUDY AT THE BACK OF HIS STATIONERY STORE IN LA PLATA.

Courtesy of Professor W. B. Scott.

Packing cases stacked against the walls and in every available space served to accommodate the boxes of fossils, and rough deal tables to lay them out for examination and study.

carried on. There is something peculiarly affecting and inspiring in the picture of this great paleontologist, maintaining through all these years of straitened circumstance a record of splendid achievement, in a field which beyond most others is supposed to require ample means in order to accomplish much that is worth while. For the most conservative of paleontologists will accord to him a record of accomplished work equalled by few of his confrères in amount and importance.

Time will show how much of Ameghino's contribution to paleontologic theory will stand. But, right or wrong, his challenging of many accepted views has compelled a reconsideration and more careful sifting of the evidence upon which they are based, which can not but be bene-

ficial, whatever conclusions it leads to. In this field he stood forth as the chief exponent of doctrines maintained against strong and widespread opposition, forced into recognition and partial acceptance by the sheer vigor and energy with which he defended them, and the learning and skill with which he marshalled a tremendous array of evidence in their support. I, who disbelieve these views and have taken some share in combating them, can well afford to honor the ability and industry with which they were defended. Heterodoxy is of the life of scientific doctrine, the surest indication of its vigor and progressiveness. Only in decadence will our theories degenerate into a "body of geologic dogma," admitted to universal belief with universal indifference.

THE PROGRESS OF SCIENCE

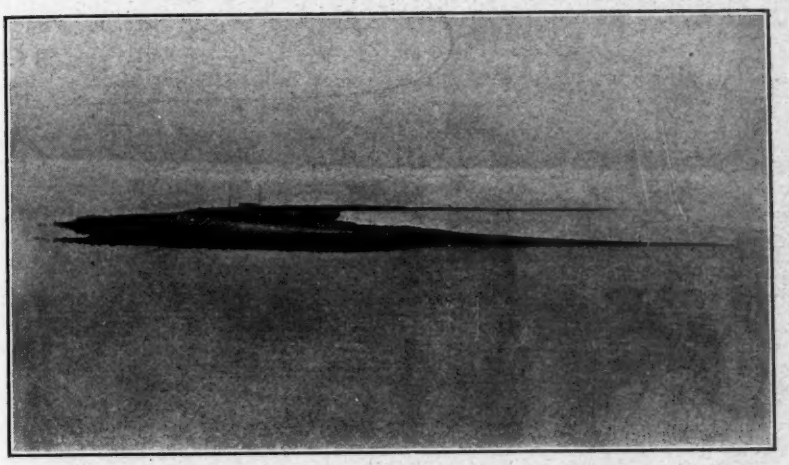
TEN YEARS OF THE CARNEGIE INSTITUTION

THE tenth yearbook of the Carnegie Institution of Washington is of special interest, as it records a further gift from the founder of ten million dollars and reviews the history of the institution for its first ten years. The endowment is now $22,000,000 in five per cent. bonds of the steel corporation, worth at least $25,000,000. The investment in property of the institution from its income is about $1,700,000 and there is a reserve fund of $250,000. During the ten years the cost of administration has been $400,000, of publication $300,000, and the sum of $4,000,000 has been applied directly to research. There have been published 201 volumes under 156 different titles.

The Carnegie Institution has definitely adopted the policy of devoting its income to the support of its own departments rather than to attempting to conduct an emergency fund for research. Some minor grants and research associates are maintained, but these also are semi-permanent in character, but few new special appropriations having been made recently. Last year about $500,000 was devoted to the ten departments of the institution.

The president states that the last fiscal year was the most fruitful on record for the ten specially organized departments of research. The solar observatory has now four telescopes—two tower telescopes, a horizontal 30-inch reflector and a 60-inch equatorial reflector. It has proved impossible to obtain a perfect cast for the 100-inch telescope, but the disc supplied by the French founders is being ground in the hope that the flaws will not interfere with its accuracy. The meridian determinations of stellar positions at the

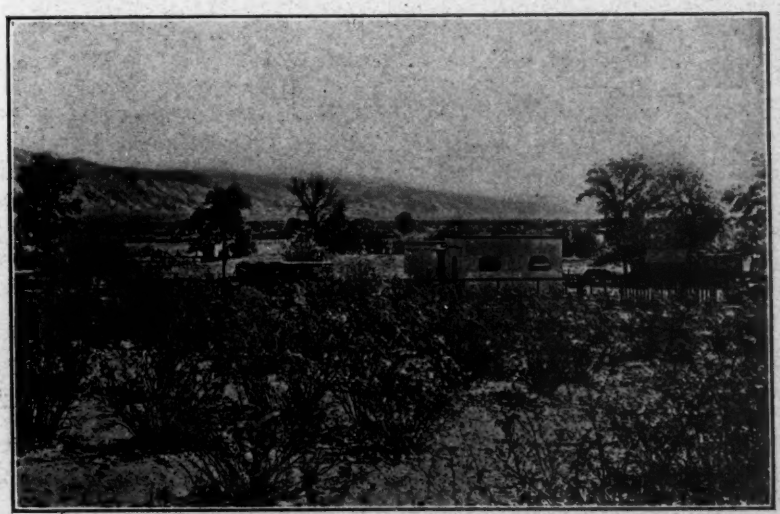
THE 100-INCH DISK ON THE GRINDING MACHINE.



GOOSE ISLAND.

temporary observatory in Argentina have been completed. The non-magnetic ship *Carnegie* has traversed some 25,000 miles, measuring magnetic declination at 252 different points. The Geophysical Laboratory has continued its work on the chemical and physical problems presented by the materials of the earth's crust. To the work in astronomy and geophysics the institution devotes considerably more than half its resources.

The nutrition laboratory and three departments devoted to the biological sciences each receive appropriations of somewhat over $30,000. The Desert Botanical Laboratory has found an interesting problem in the results following the drying up of the Salton Sea, and has carried on researches on the effects on plants of altitude, dryness and other factors. The Department of Marine Biology has constructed a yacht, named in honor of the founder of the Naples Botanical Station, which enables it to carry on work



SCENE AT THE DESERT LABORATORY.

in addition to that undertaken on the Tortugas.. The Department of Experimental Evolution has, among other work, collaborated with the Eugenics Record Office in the study of human heredity, constructed a vivarium for cave life and used Goose Island to study the changes a domesticated species undergoes in becoming feral.

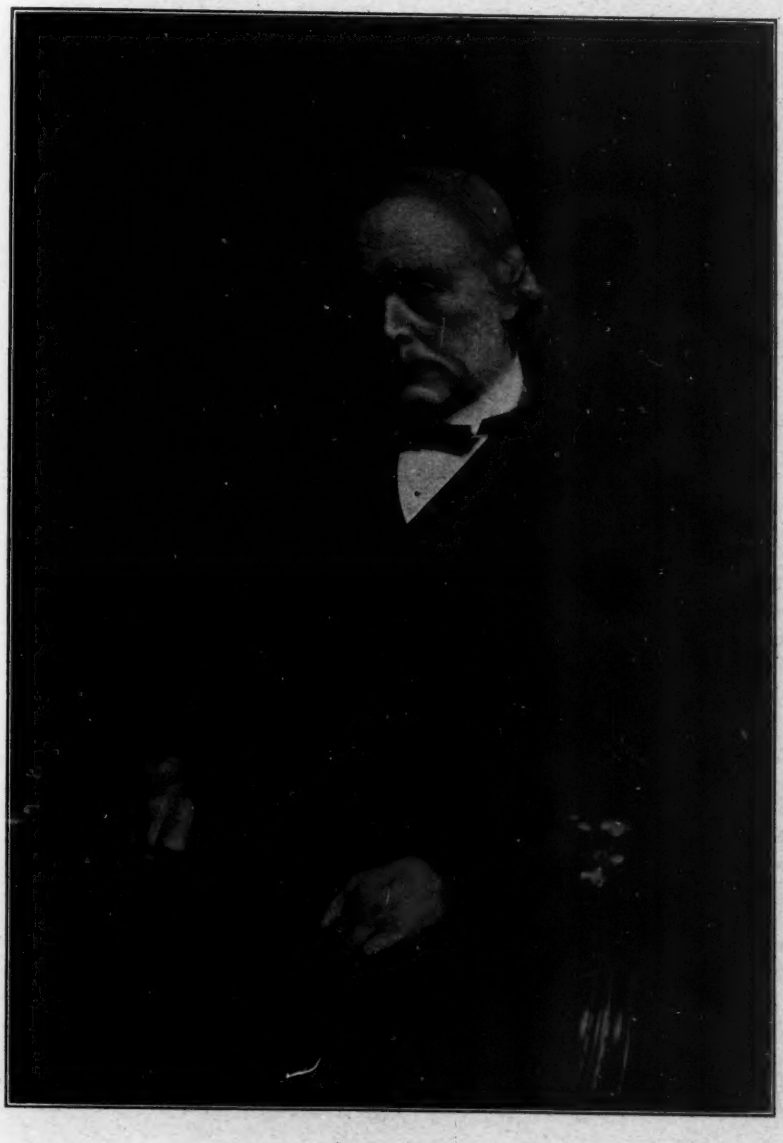
Endowed institutions for research are of vast importance for the progress of science. Under existing social conditions investigation can not be undertaken as an independent profession. The sales of the publications of the Carnegie Institution are less than one per cent. of the cost of the work which they represent. It is necessary that society should in some way pay for the research work which is of benefit to society as a whole, but can not be sold to an individual. In Germany investigation has in the main been carried forward in connection with university chairs, and during the nineteenth century remarkable results were obtained with a small expenditure. In England much of the most important scientific work has been produced by men having inherited wealth. In this country our universities have not yet equalled those of Germany in their productiveness, and we have but few amateurs.

The United States has, however, taken the lead in the amount of scientific work done under the government, and the two foundations for research endowed by Mr. Carnegie and Mr. Rockefeller have larger resources than those of any other nation. After the efflorescence of the medieval universities there was a period in the seventeenth and eighteen centuries during which the academies of sciences and the newly-established observatories, museums and botanical gardens became the most important centers of research. Perhaps the institutions endowed for research will in the twentieth century be the chief centers of scientific investigation. We may, however, hope that the universities, the research institutions, the national, state and municipal governments and industrial enterprises will unite to advance science and its applications. The United States has the largest natural resources of any nation, and in so far as these are used, the proceeds should in large measure be expended on scientific work, which will provide an economic equivalent for the fertility of the soil, the forests, the mining products and other natural resources which we are consuming.

LORD LISTER

In recording the death of Francis Galton somewhat less than a year ago, it was noted here that of the great men of science who gave distinction to the Victorian era only three remained —Hooker, Wallace and Lister. Hooker has since died at the age of ninety-four years and on February the eleventh Lister died at the age of eighty-four years. An English journal recently compiled a list of the ten greatest men of the world, and Lister would perhaps have been the name on which there would have been the most general agreement. Like Galton and Hooker, Lister had distinguished scientific ancestry, his father having been a fellow of the Royal Society, who, among many other services, gave us the existing compound microscope.

Joseph Lister was born at Upton in Essex on April 5, 1827. He received the degree of bachelor of medicine in 1847 and that of doctor of medicine in 1852 from the University of London. While house surgeon at University College Hospital he made researches on gangrene and pyemia. In 1856 he became assistant surgeon in Edinburgh Royal Infirmary, in 1860 professor of surgery at Glasgow University, in 1869 professor at Edinburgh University and in 1877 at King's College, London. He was created a baronet in 1883 and was raised to the peerage in 1893, with the title of Baron Lister of Lyme Regis. In Edinburgh he married the daughter of Professor Syme, the emi-



LORD LISTER.

nent surgeon, to whose chair he succeeded. His nephew is a leading man of science, but he left no children.

It was at Glasgow, where the infirmary was a hotbed of septic disease, that Lister, using the discovery of Pasteur that decomposition in organic substances is due to living germs which are descended from parents like themselves, applied the antiseptic treatment in surgery, an advance only paralleled by that of the discovery of antiseptics. It was not an isolated discovery, but was preceded and followed by important researches, which led up to it and perfected it. Perhaps no one else has accomplished so much as Lister for the relief of suffering and the prevention of premature death.

SCIENTIFIC ITEMS

WE record with regret the death of Professor George Jarvis Brush, the eminent mineralogist of Yale University, and of Dr. Waldemar Koch, of the University of Chicago, known for his researches in physiological chemistry.

M. LIPPMAN has been elected president, and Professor Guyon vice-president, of the Paris Academy of Sciences.—The Academy of Sciences at Bologna has awarded the Élie de Cyon prize of 3,000 lire to Professor E. A. Schäfer, of Edinburgh.—Among the British honors are knighthoods conferred on Professor W. F. Barrett, F.R.S., formerly professor of physics in the Royal College of Science, Dublin, and Professor E. B. Tylor, F.R.S., emeritus professor of anthropology in the University of Oxford.—It is proposed to have painted and to present to the American Philosophical Society a portrait of its president, Dr. William W. Keen, who, on January 19, celebrated his seventy-fifth birthday.